TISSUE

Anatomy & Physiology 1

Types Of Tissues And Their Origins

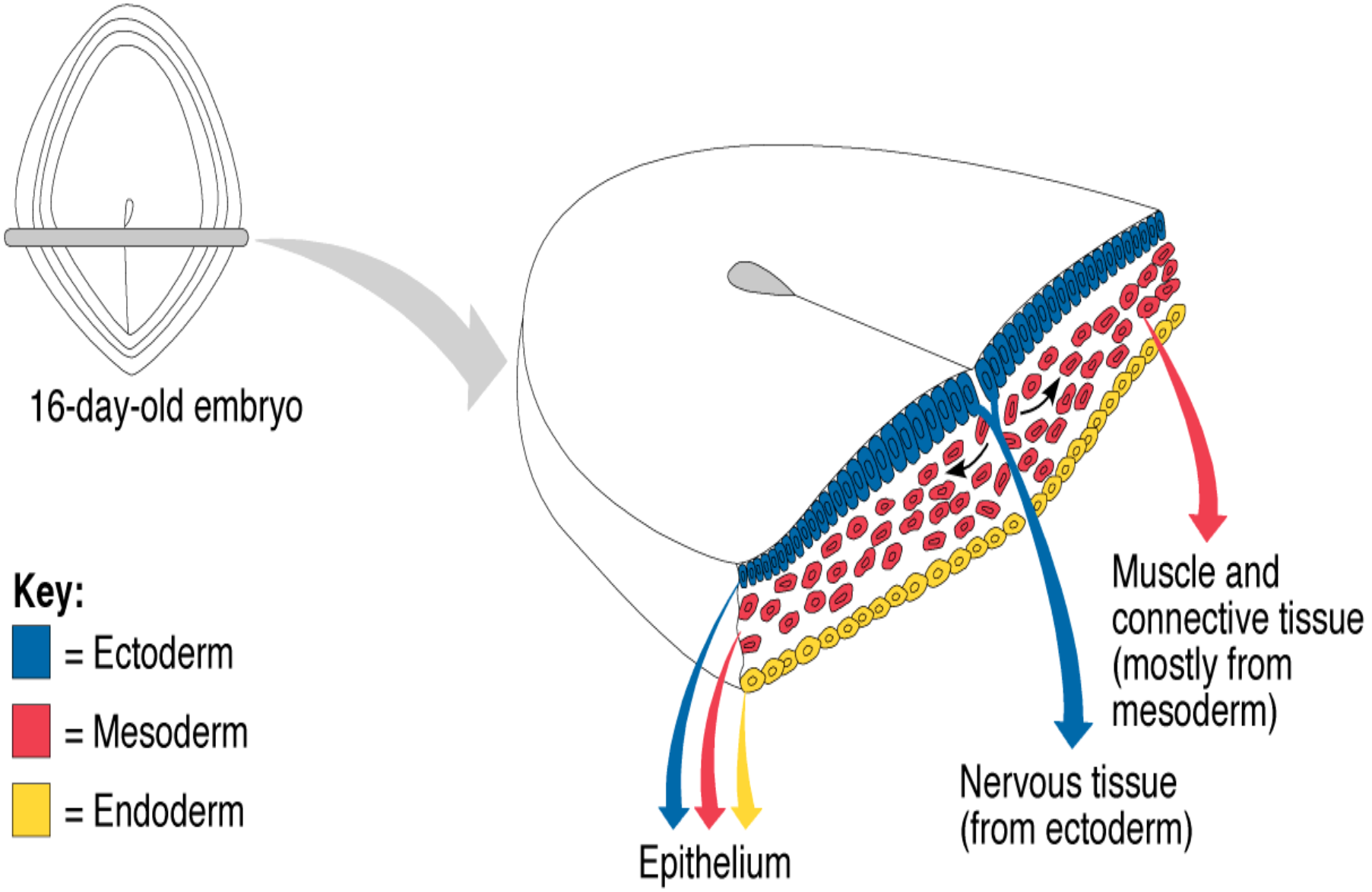
- Depending on their function and structure, the various tissues of the body are classified into four principal types.
  - ***Epithelial tissue*** covers body surfaces, lines hollow organs, body cavities, and ducts; and forms glands.

Types Of Tissues And Their Origins

- ***Connective tissue*** protects and supports the body and its organs, binds organs together, stores energy reserves as fat, and provides immunity.
- ***Muscle tissue*** is responsible for movement and generation of force. *Nervous tissue* initiates and transmits action potentials (nerve impulses) that help coordinate body activities.

Types Of Tissues And Their Origins

- All tissues and organs of the body develop from one or more of the three primary germ layers: *ectoderm*, *endoderm*, and *mesoderm*.
  - Table 29.1 provides a list of structures derived from the primary germ layers.



Types Of Tissues And Their Origins

- Normally, most cells within a tissue remain in place, anchored to other cells, basement membranes, or connective tissues.
- Exceptions include phagocytes and embryonic cells involved in differentiation and growth.

DEFINITION

- Tissue
  - Groups of cells of common origin
  - Cells with a common function
  - Carry out specialized activity

EXTRACELLULAR MATERIALS

- These are substances contributing to body mass that are found outside the cells.
- One class is **Body Fluids:**
  - **Interstitial fluid –** derived from blood
  - **Blood plasma**
  - **Cerebrospinal fluid**
- These fluids are important as transport and dissolving media.

EXTRACELLULAR MATERIALS

- Another class is **Cellular Secretions:**
  - **Intestinal and gastric fluids**
  - **Saliva, mucus, and serous fluids**
- These fluids are important in digestion and act as lubricates.

EXTRACELLULAR MATERIALS

- However the most abundant of the extracellular materials is the **Extracellular Matrix**
- Most body cells are in contact with a jellylike substance composed of proteins and polysaccharides.

EXTRACELLULAR MATERIALS

- This material is secreted by the cells and forms an organized mesh in the extracellular space where they serve as a universal “cell glue” that helps hold body cells together.

PRIMARY TISSUES

- Epithelial tissue
- Connective tissue
- Muscle tissue
- Nervous tissue

Cell Junctions

- *Cell junctions* are points of contact between adjacent plasma membranes.
  - Depending on their structure, cell junctions may serve one of three functions.
  - Some cell junctions form fluid-tight seals between cells.

Cell Junctions

- Other cell junctions anchor cells together or to extracellular material.
- Still others act as channels, which allow ions and molecules to pass from cell to cell within a tissue.

Cell Junctions

- The five most important kinds of cell junctions are:
  - Tight Junctions
  - Adherens Junctions,
  - Desmosomes,
  - Hemidesmosomes, and
  - Gap Junctions.

Intercellular Junctions.

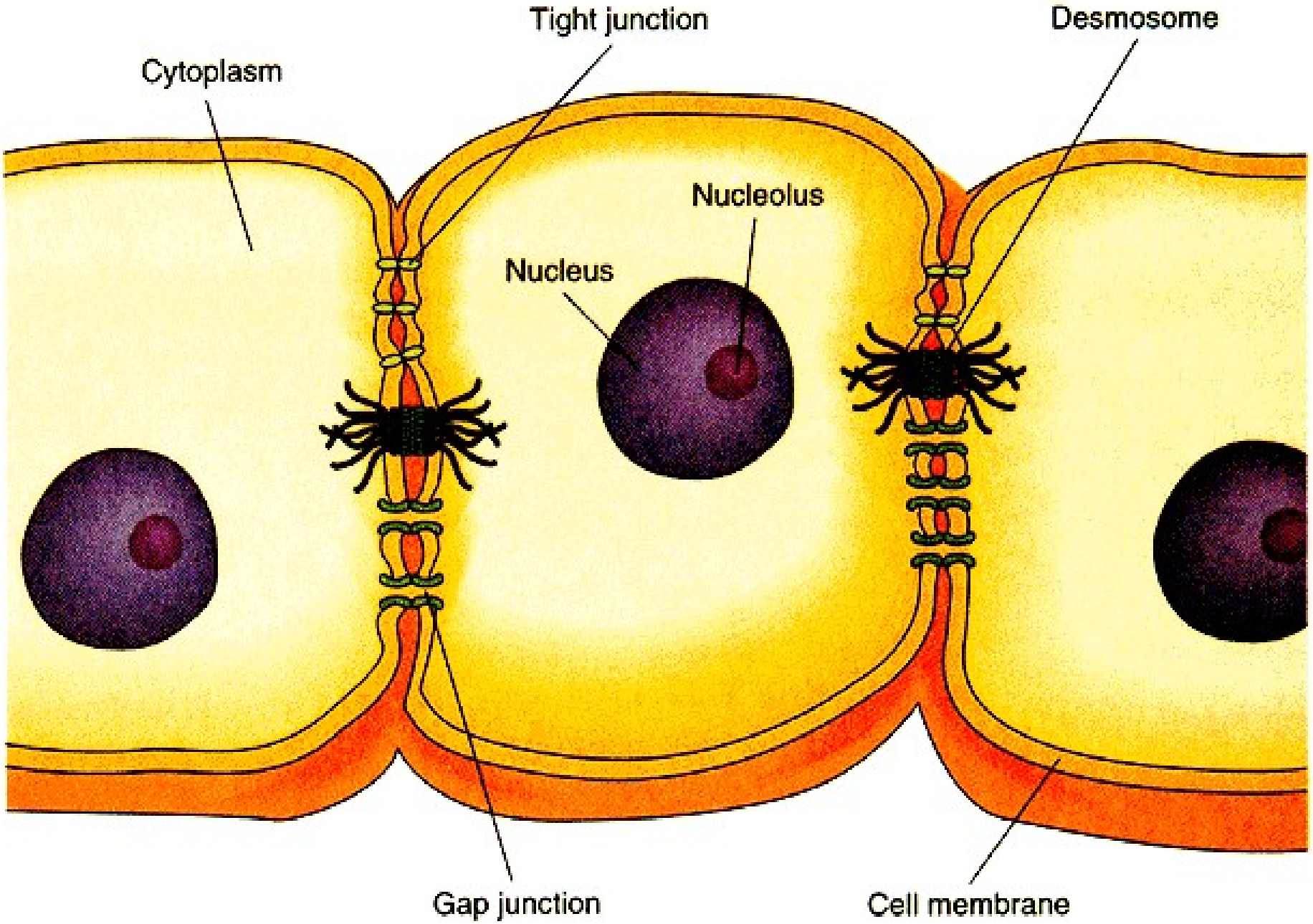
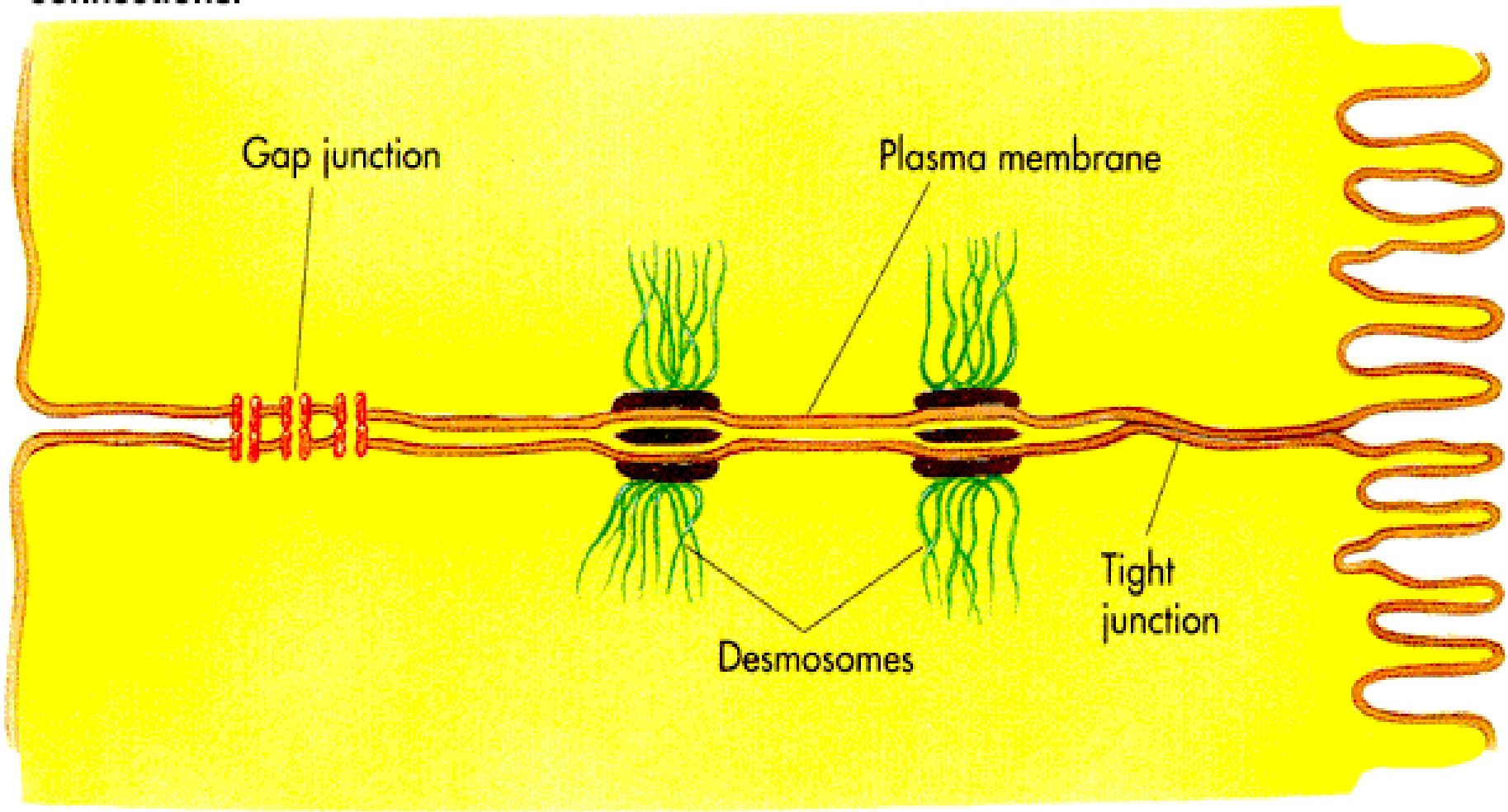
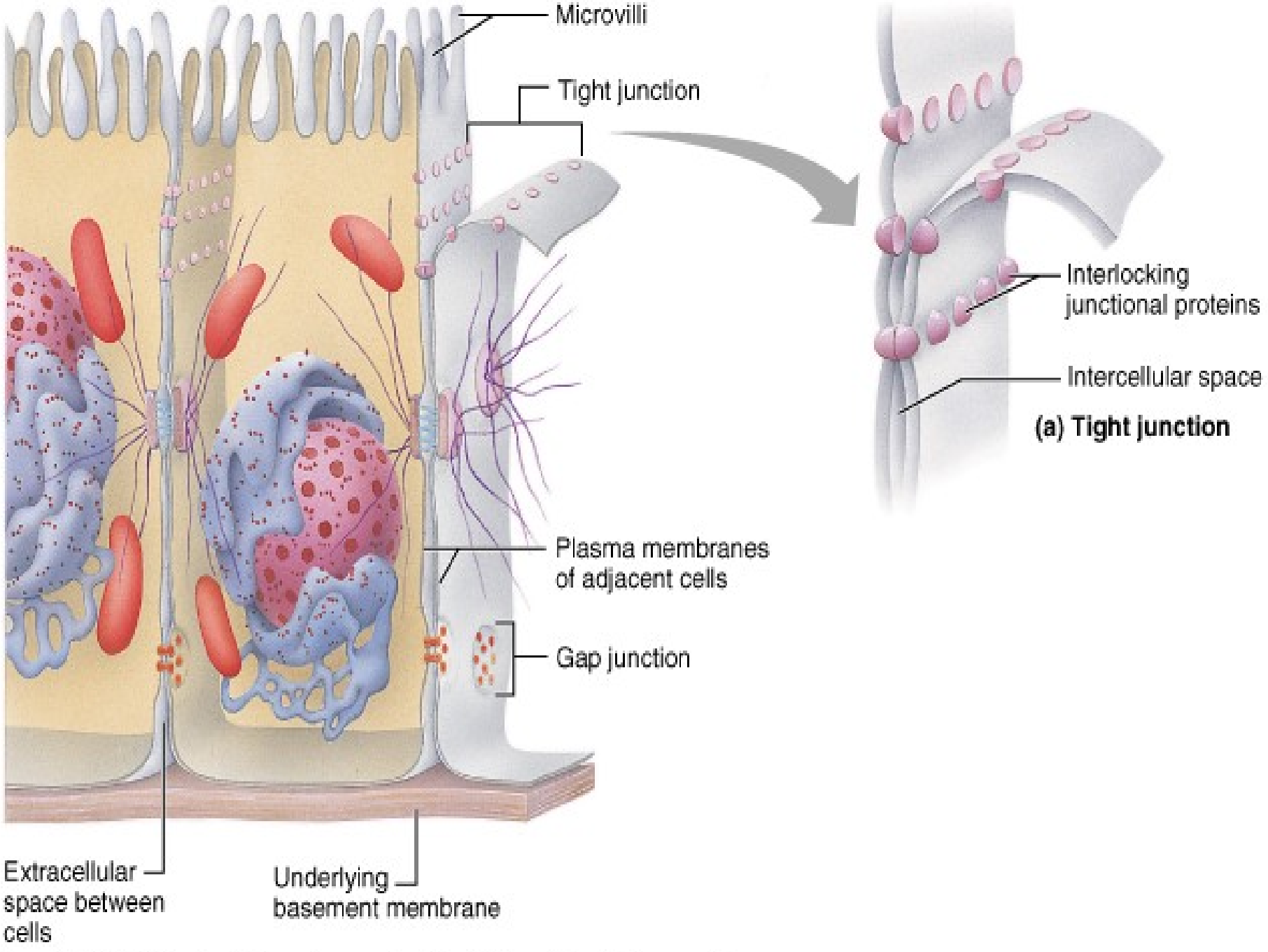


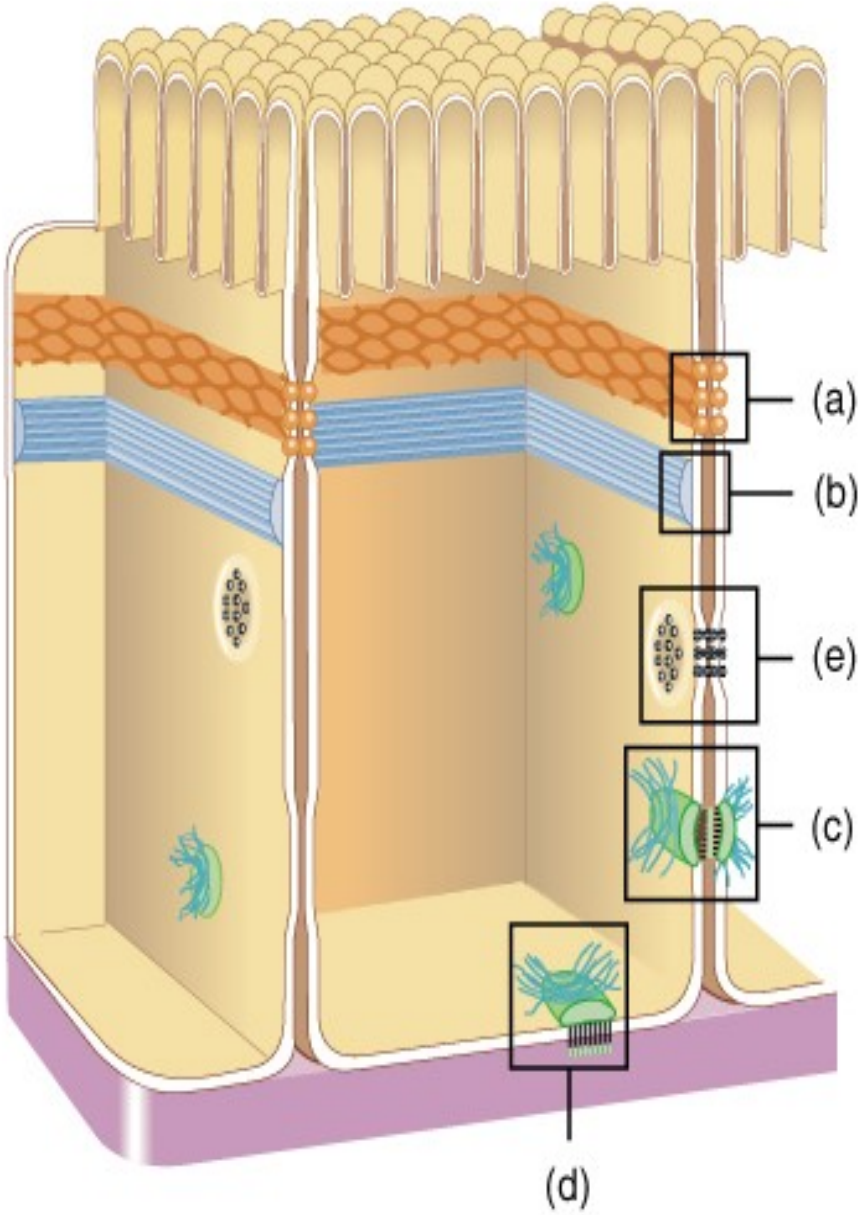
Figure 5
The three principal types of intercellular connections.

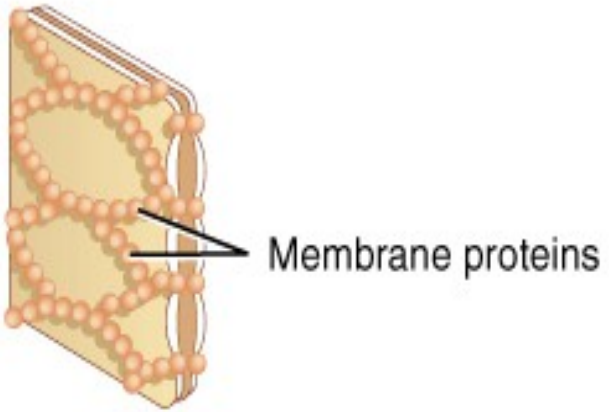


Cell Junctions

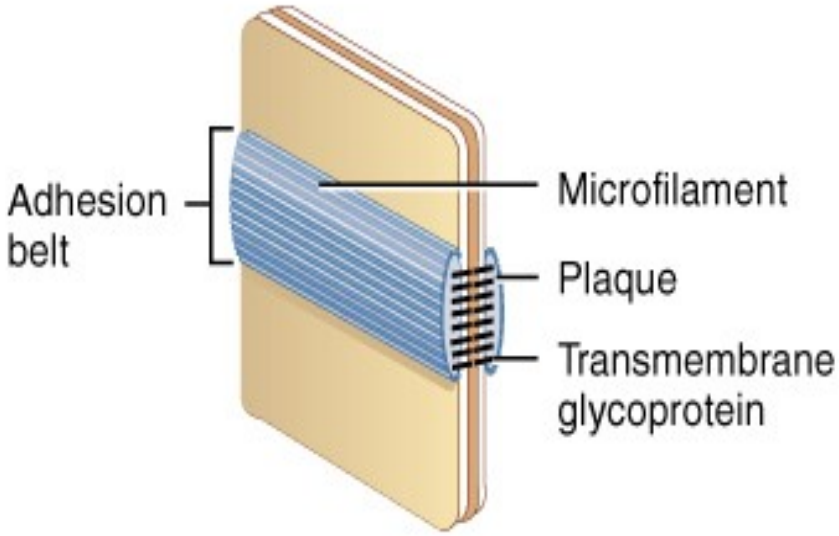
- *Tight junctions* form fluid-tight seals between cells and are common among epithelial cells that line the stomach, intestines, and urinary bladder.
- *Adherens junctions* are made of plaque and anchor cells together.


Microvilli
Tight junction
Plasma membranes of adjacent cells
Gap junction
Extracellular space between cells
Underlying basement membrane
Interlocking junctional proteins
Intercellular space
(a) Tight junction





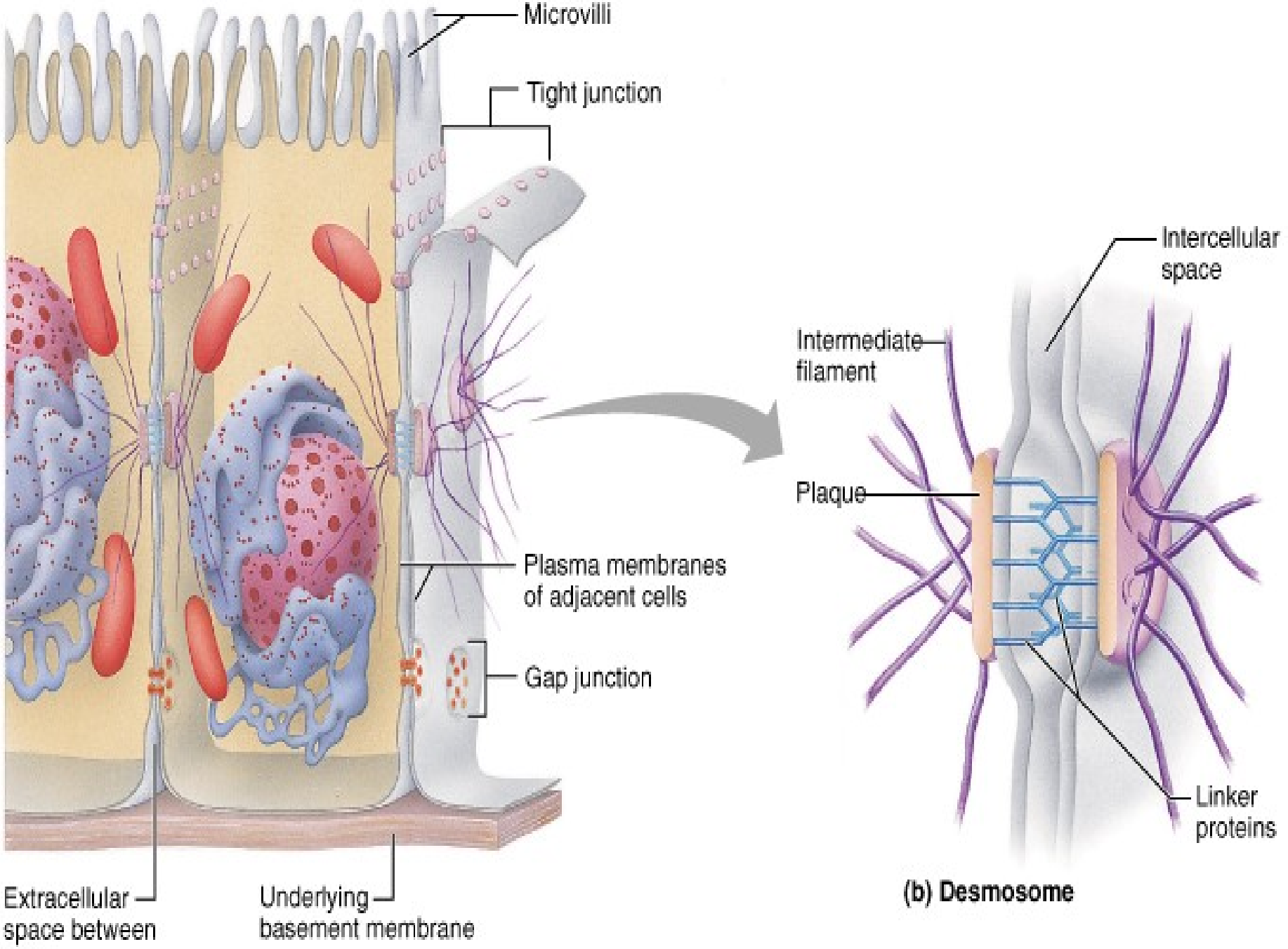
(a) Tight junction

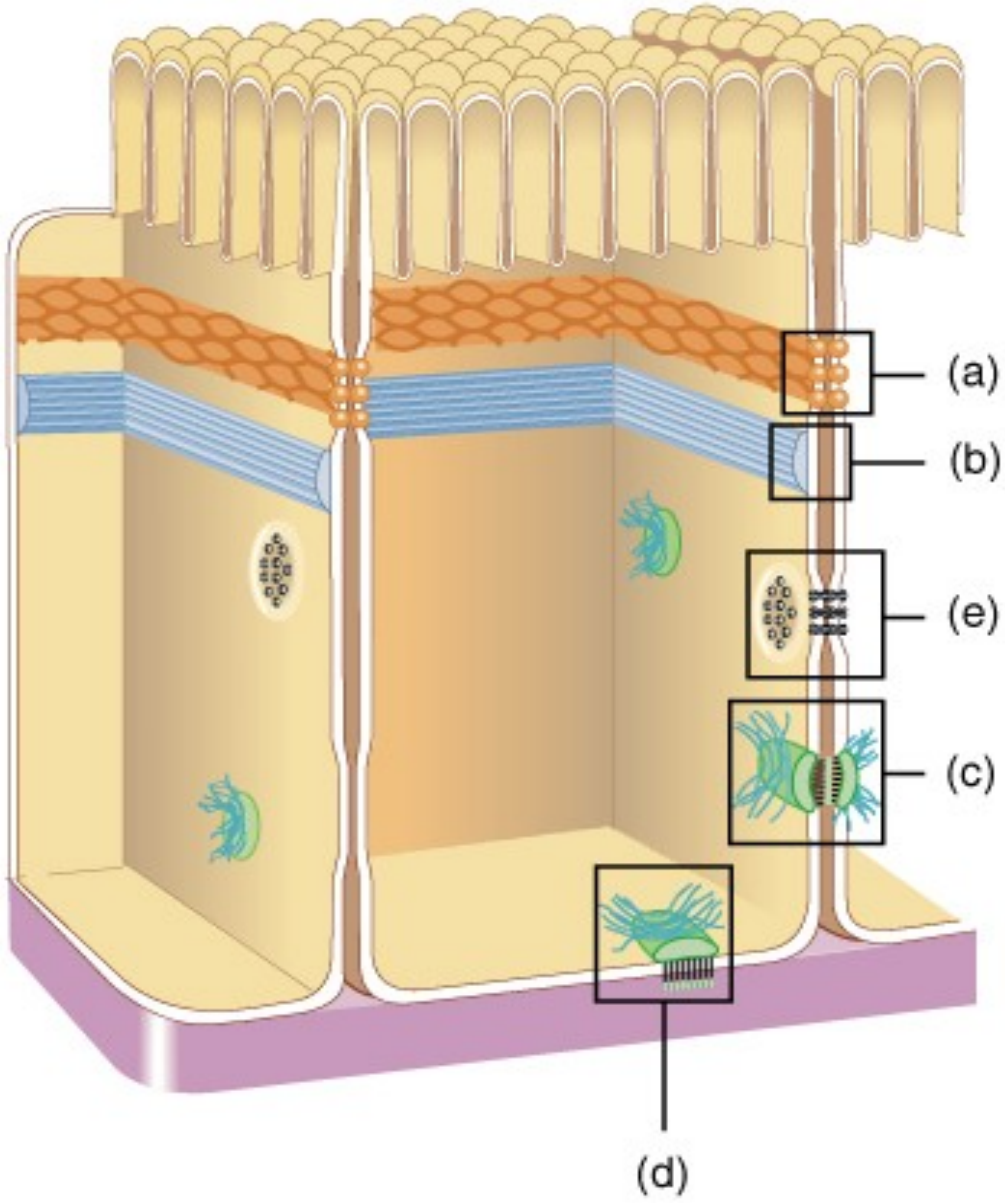


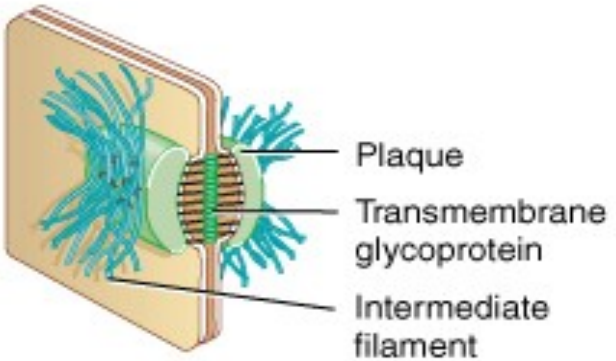
(b) Adherens junction

Cell Junctions

- *Desmosomes* are composed of plaque and are linked by transmembrane glycoproteins that extend across a gap between adjacent cell membranes and link the cytoskeletons of cells together.
- *Hemidesmosomes* connect cells to extracellular material such as the basement membrane.

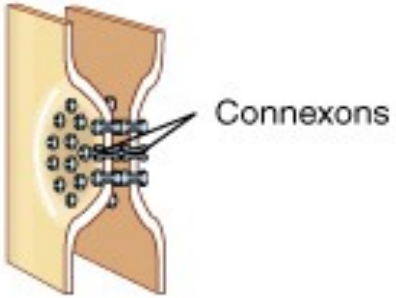

Microvilli
Tight junction
Plasma membranes of adjacent cells
Gap junction
Extracellular space between cells
Underlying basement membrane
Intercellular space
Intermediate filament
Plaque
Linker proteins
(b) Desmosome





(c) Desmosome

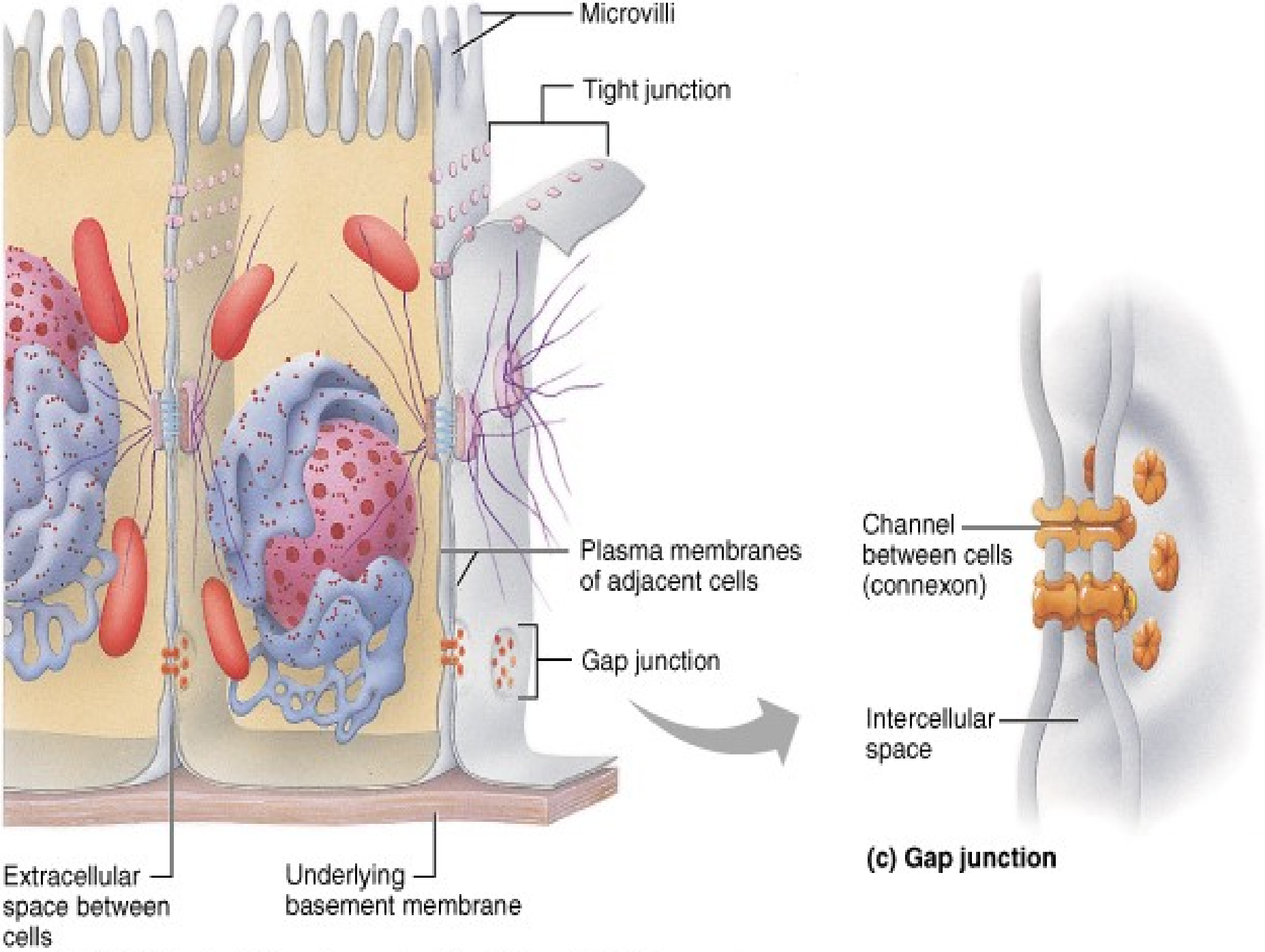
(d) Hemidesmosome

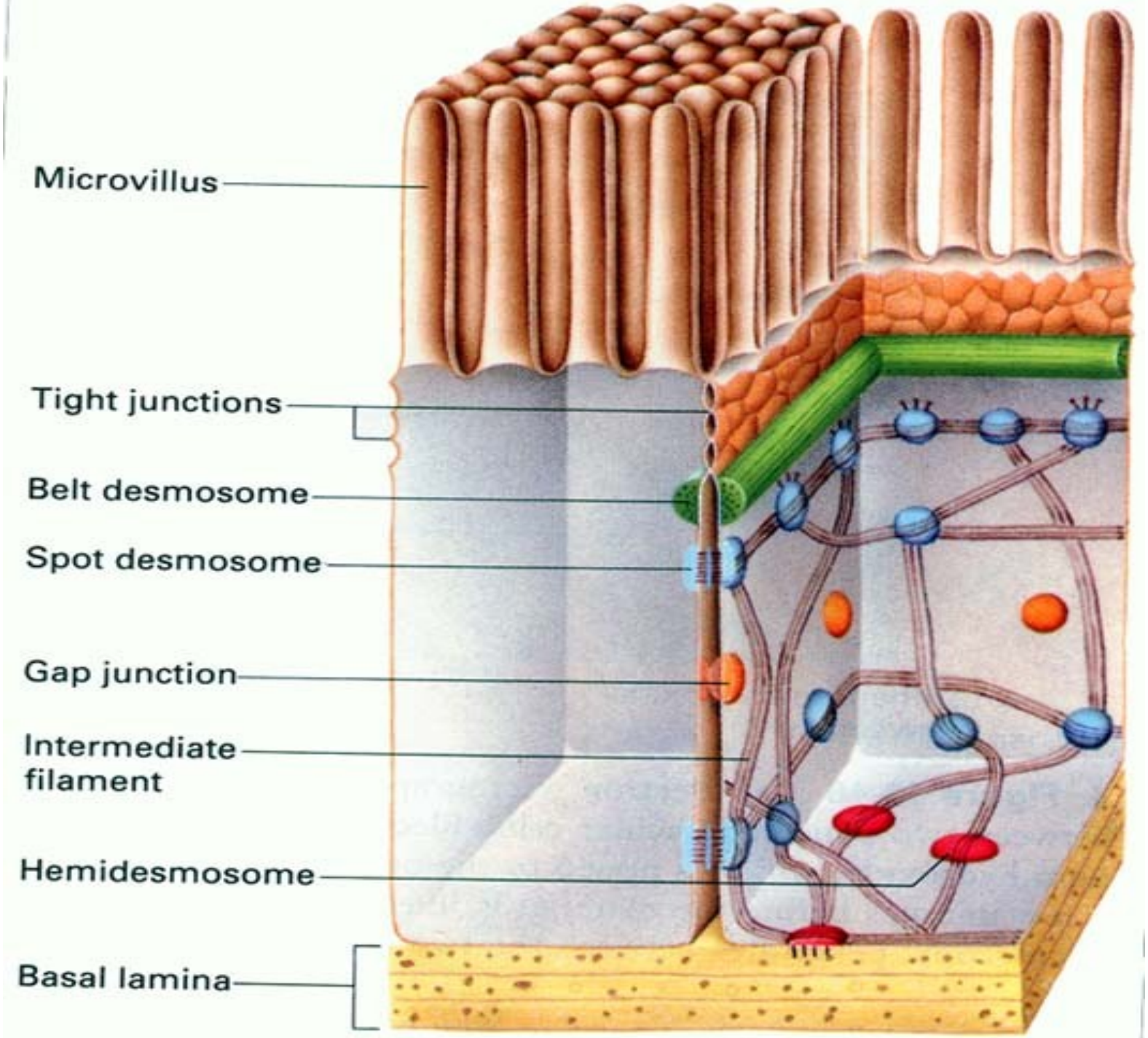


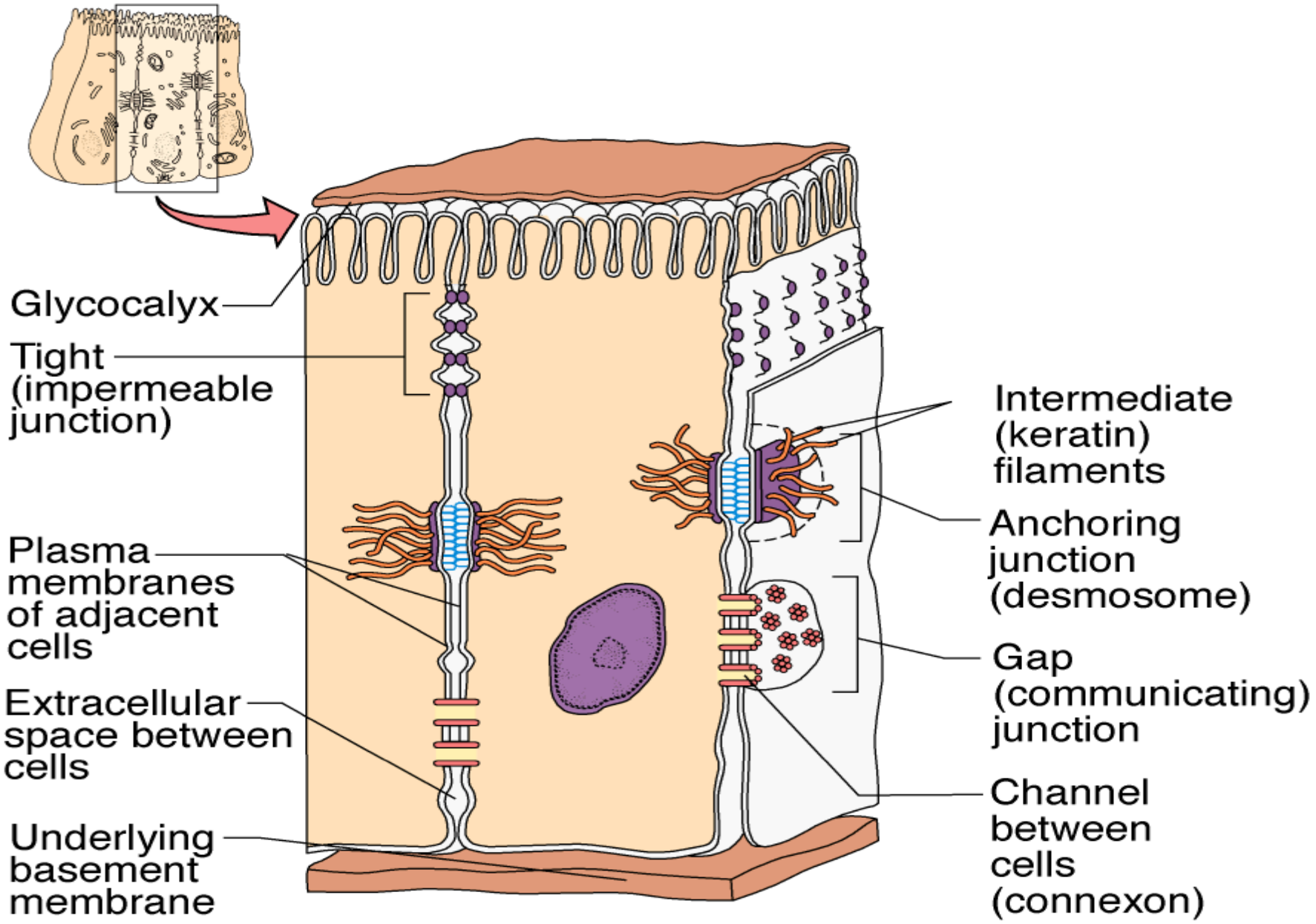
(e) Gap junction

Cell Junctions

- *Gap junctions* allow cells in a tissue to rapidly communicate through *connexons*, transmembrane protein channels that connect cells together.


Microvilli
Tight junction
Plasma membranes of adjacent cells
Gap junction
Extracellular space between cells
Underlying basement membrane
Channel between cells (connexon)
Intercellular space
(c) Gap junction


Microvillus
Tight junctions
Belt desmosome
Spot desmosome
Gap junction
Intermediate filament
Hemidesmosome
Basal lamina



Epithelial Tissues

- General Features of Epithelial Tissues:
  - Epithelial cells are arranged in sheets, in either single or multiple layers.
  - Epithelium consists mostly of packer cells with little extracellular material.
  - Many cell junctions are present, providing secure attachments among cells.

Epithelial Tissues

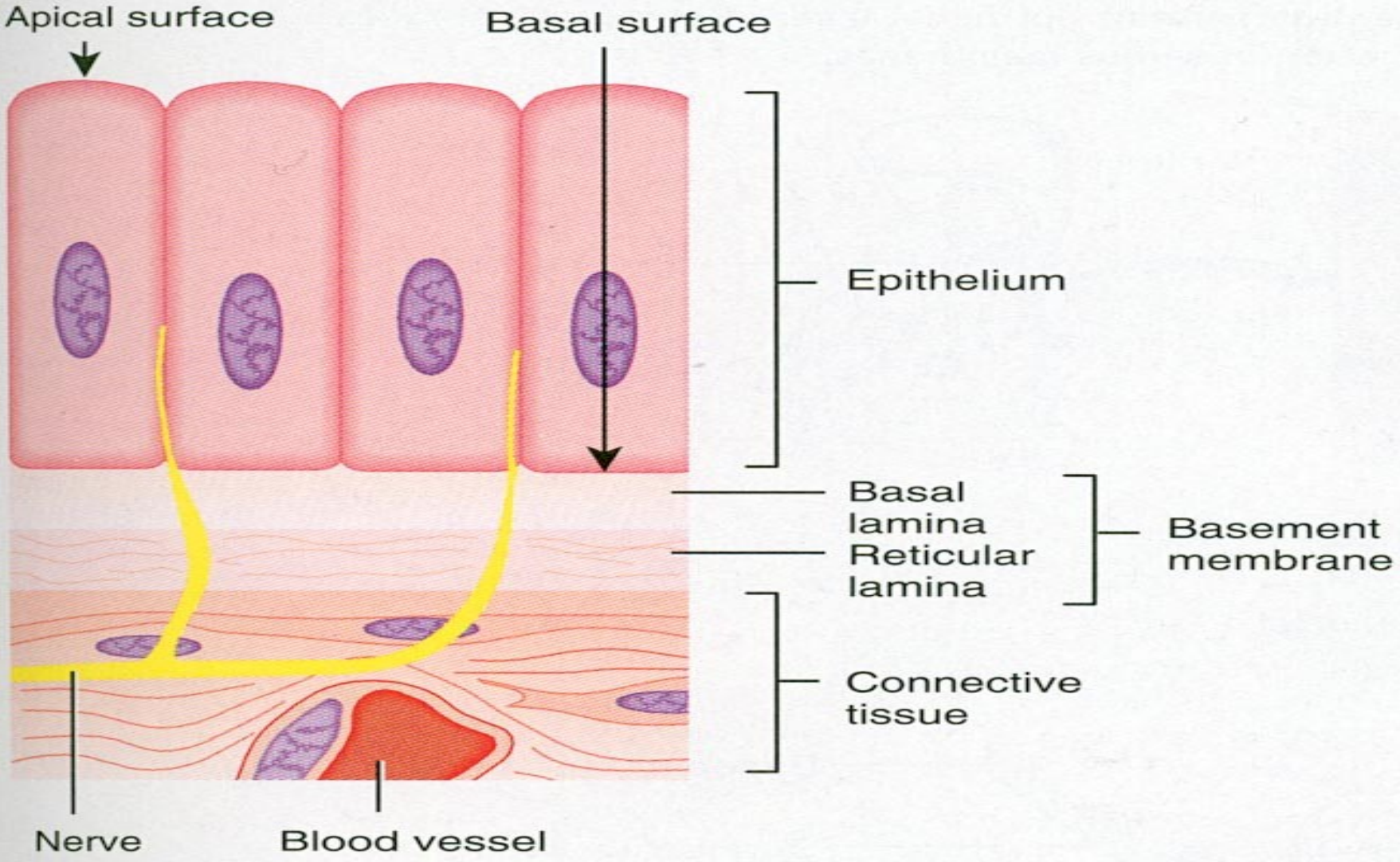
- An epithelial cell has an *apical surface* and a *basal surface* attached to a **base membrane** (Fig. 4.2).
- Epithelia adhere firmly to nearby connective tissue via a thin extracellular layer, the **basement membrane**.
- Epithelial tissue is ***avascular***; exchange of materials between epithelium and adjacent connective tissue is by diffusion.
- Epithelia have a nerve supply.

Basement Membrane

- *Basal lamina* contains collage fibers and other proteins
- *Reticular lamina* contains structural proteins, such as reticular fibers & fibronectin.

Figure 4.2 Surfaces of epithelial cells and the structure and location of the basement membrane.

The basement membrane is found between epithelium and connective tissue.

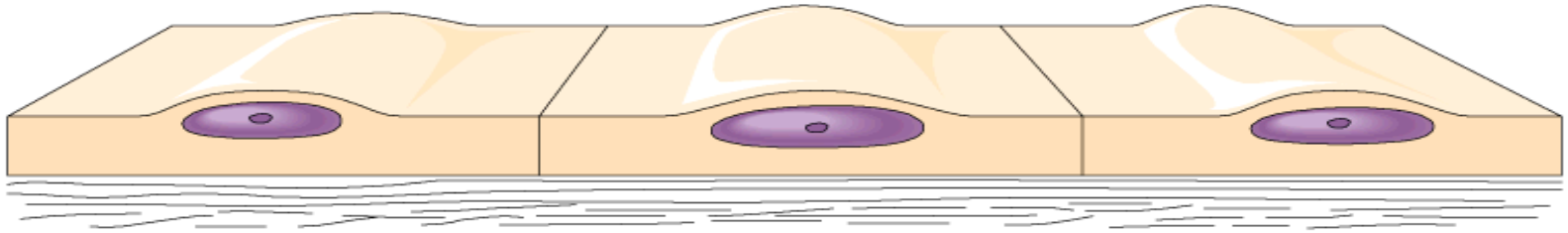


Epithelial Tissues

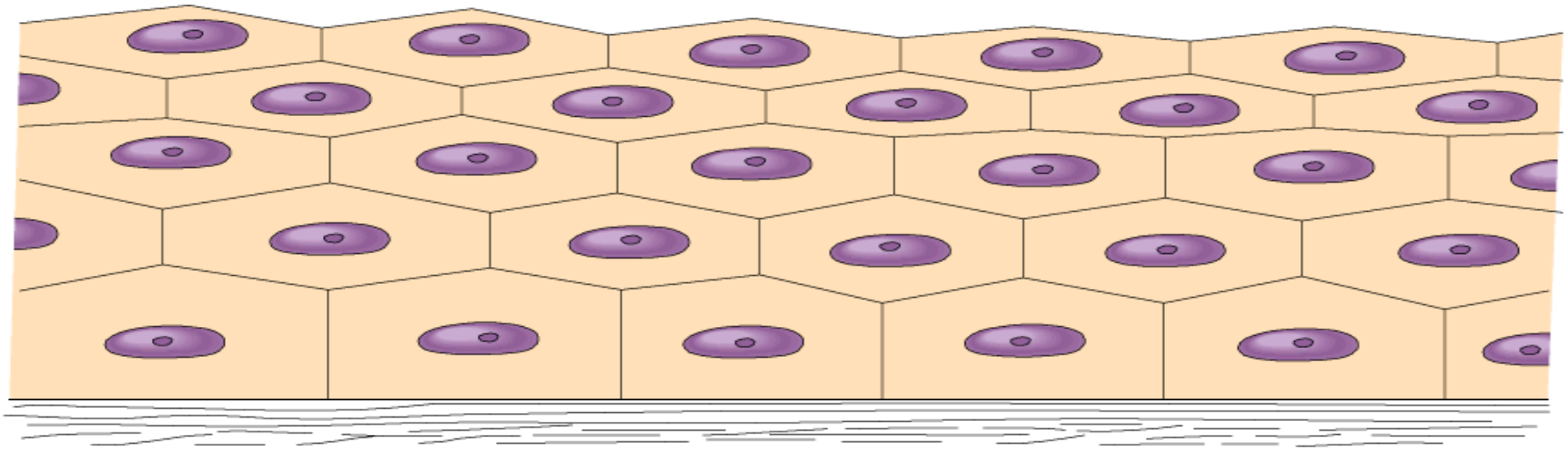
- Epithelia have a high capacity for renewal (a high mitotic rate).
- Functions of epithelia include protection, filtration, lubrication, secretion, digestion, absorption, transportation, excretion, sensory reception, and reproduction.
- The subtypes of epithelium include covering and lining epithelium and glandular epithelium.

LINING EPITHELIUM

- Covering for internal organs
- Skin
- May consist of single layer- Simple or Stratified



Simple

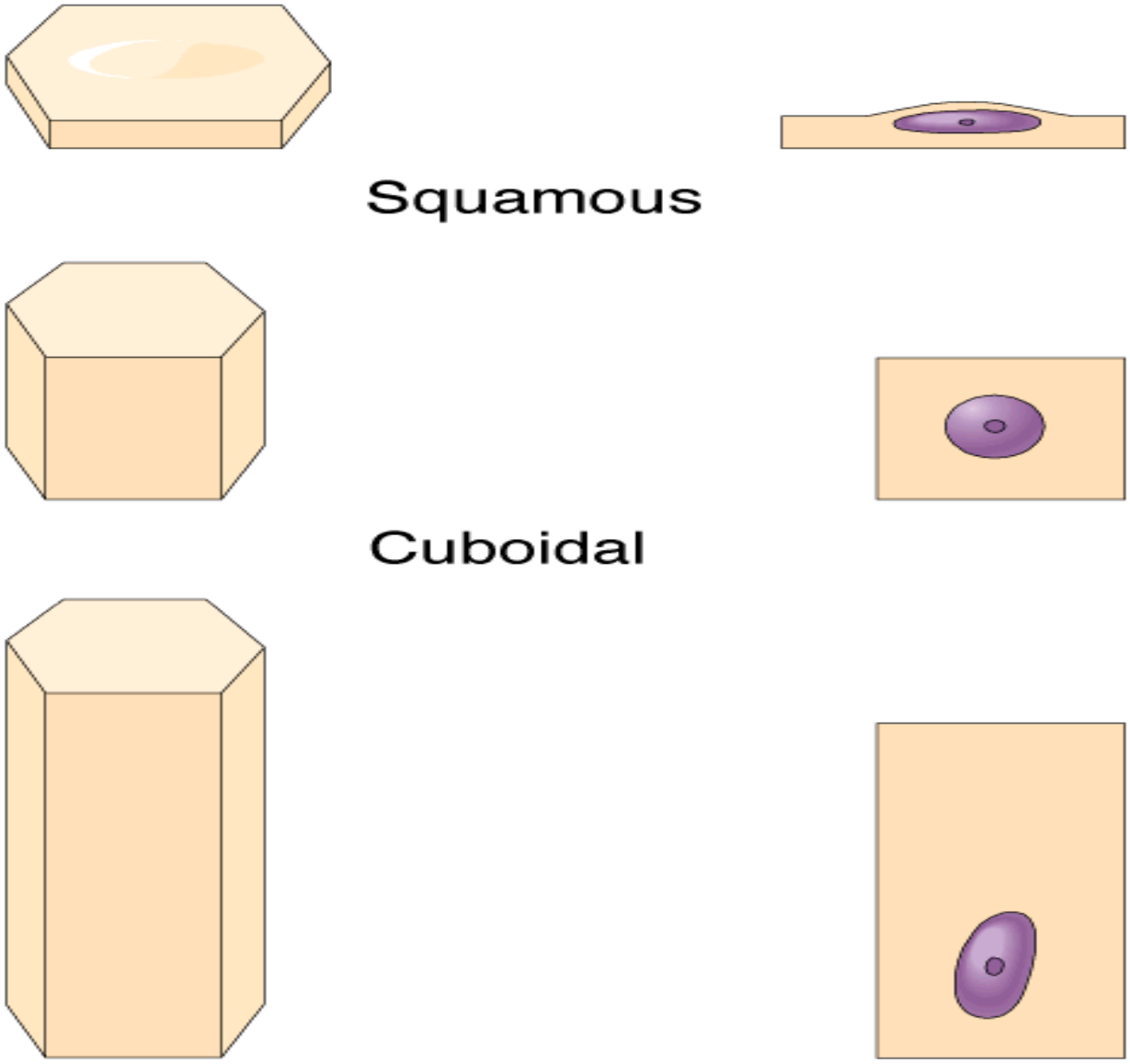


Stratified

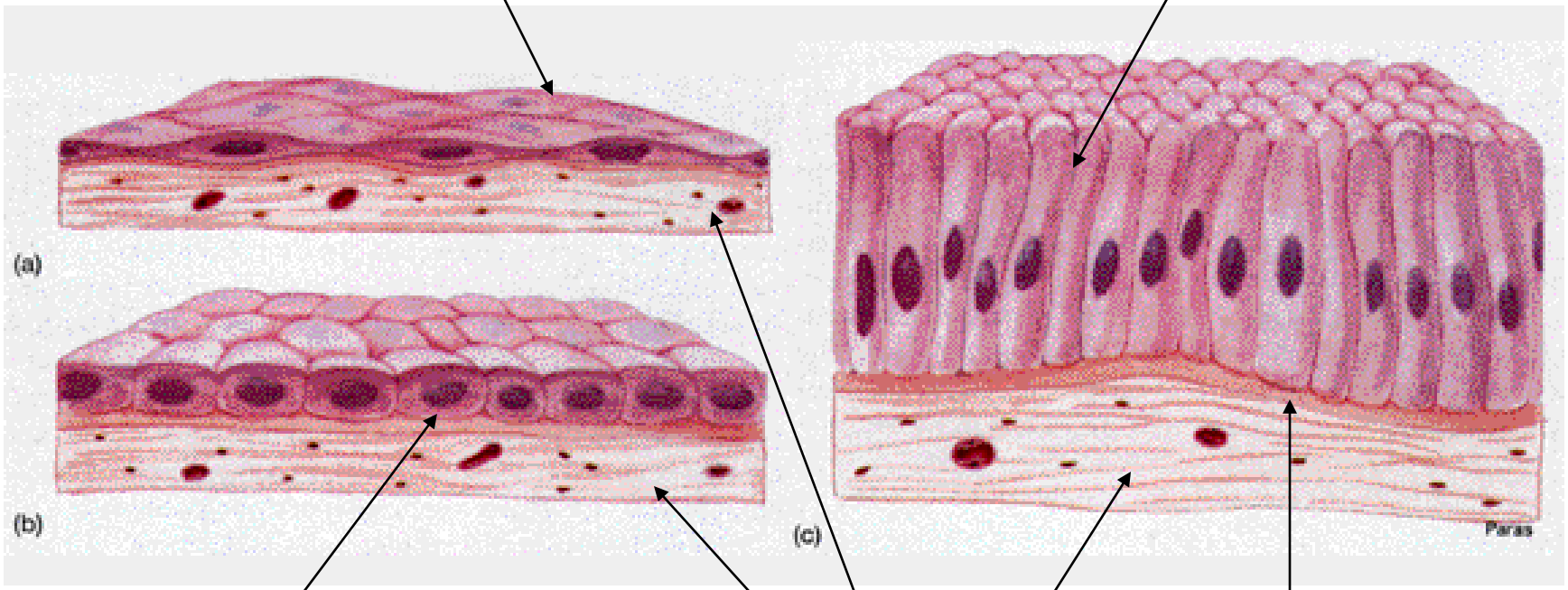
(a)

LINING EPITHELIUM

- Named for shape or function
  - Squamous (wear, tear)
  - Cuboidal
  - Columnar
  - Transitional
    - Changes shape
    - Lines urinary bladder



(b)


Squamosal (flat) cells
Columnar cells
(a)
(b)
(c)
Cuboidal cells
Basement membrane
Underlying connective tissue

Covering & Lining Epithelium

- Classification - the eight types of covering and lining epithelial tissue are classified according to the way the cells are arranged in layers.
  - Layers are arranged as *simple* (one layer), *stratified* (several layers), and *pseudostratified* (one layer that appears as several).

Lining Epithelium

- Epithelial tissue is also classified by the characteristic shape of cell.
  - Cell shapes include *squamous* (flat), *cuboidal* (cube-like), *columnar* (rectangular), and *transitional* (variable).

Lining Epithelium

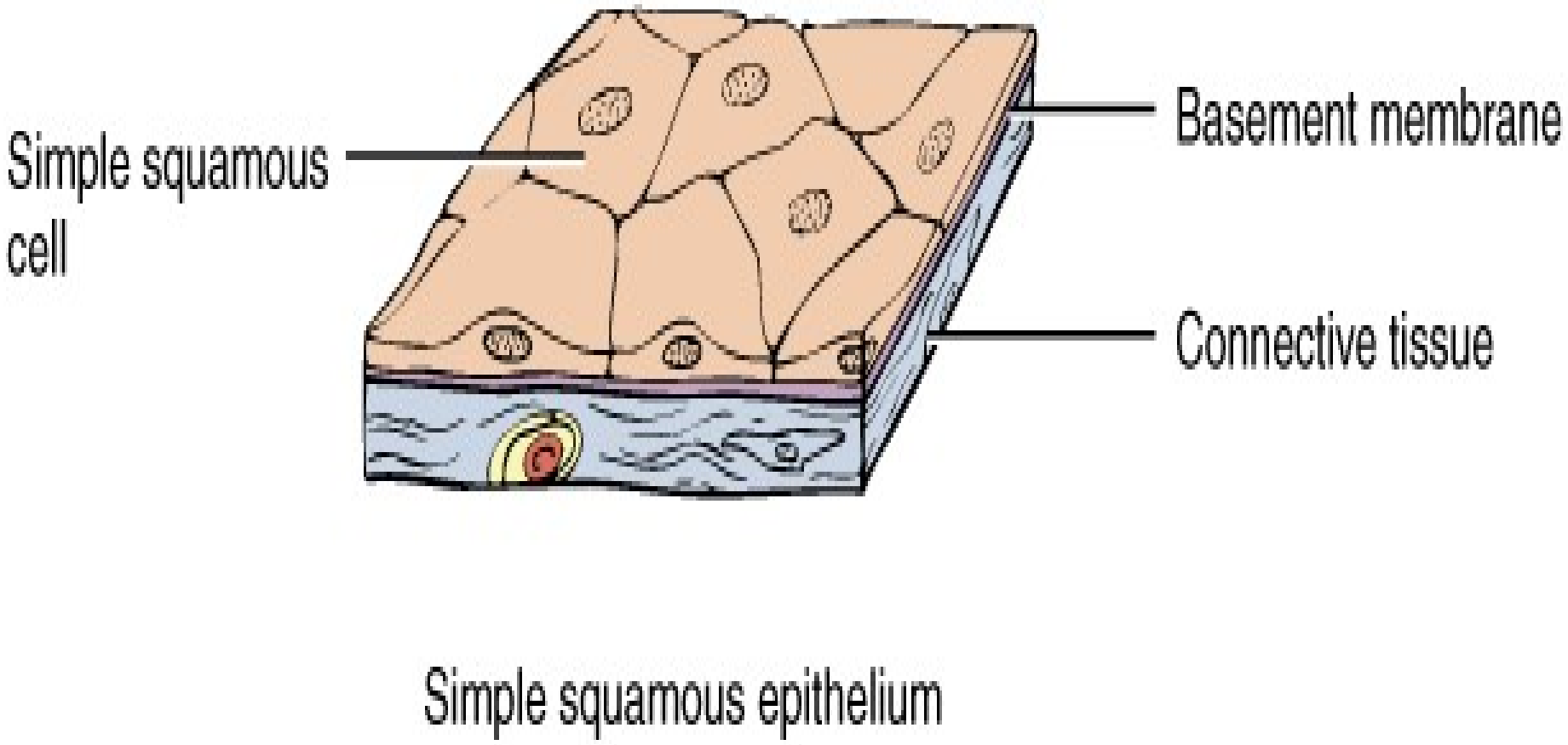
- Covering and lining epithelia may be classified as a combination of arrangement of layers and shape of the cells.
  - The name of the specific type of stratified epithelium depends on the shape of the surface cells.

Simple Epithelium

- *Simple squamous epithelium* consists of a single layer of flat, scalelike cells
  - It is adapted for diffusion and filtration and is found in lungs and kidneys.
  - It is found in parts of the body that are subject to little wear and tear.

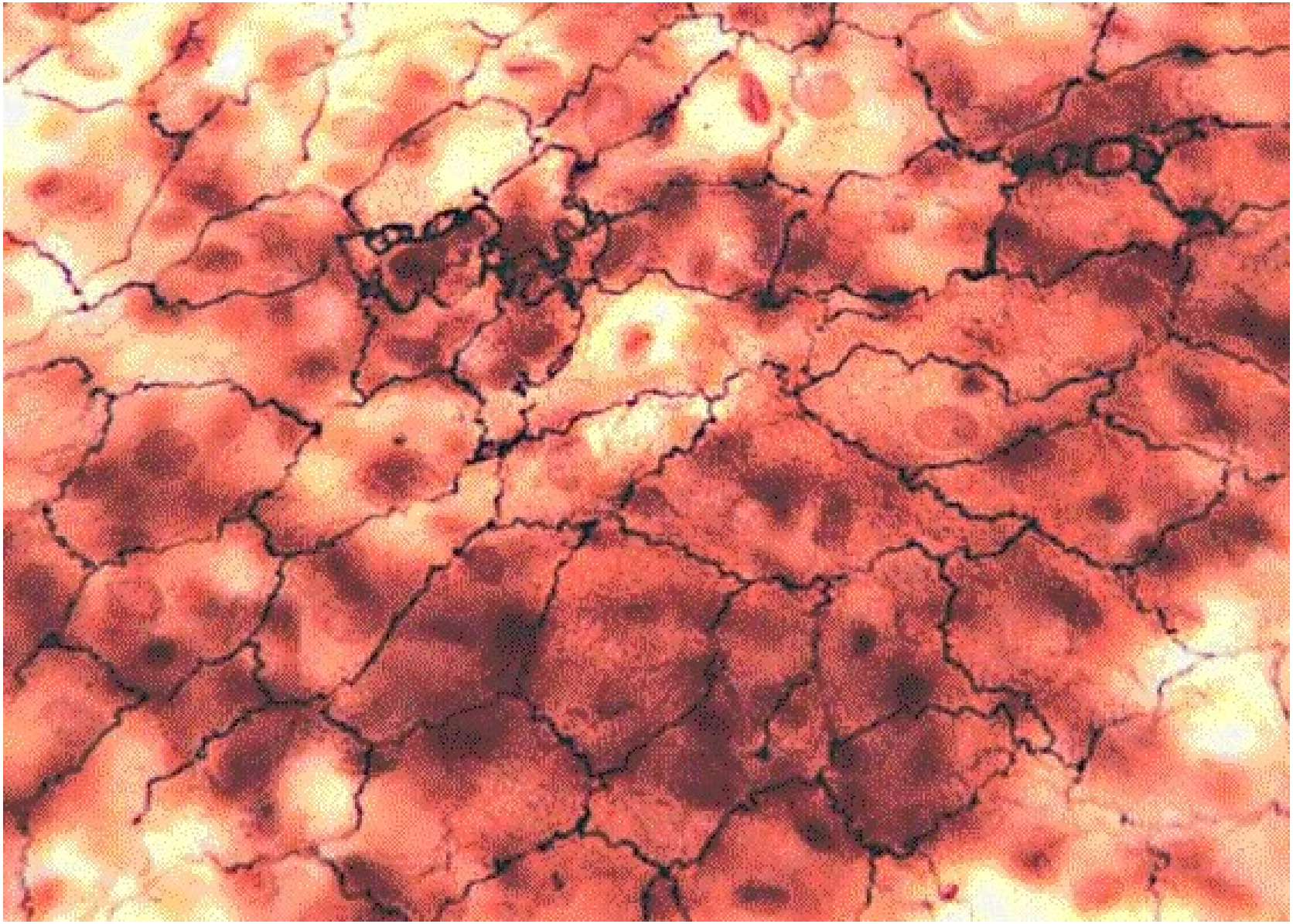
Simple Epithelium

- *Endothelium* lines the heart and blood vessels.
- *Mesothelium* lines the thoracic and abdominopelvic cavities and covers the organs within them.



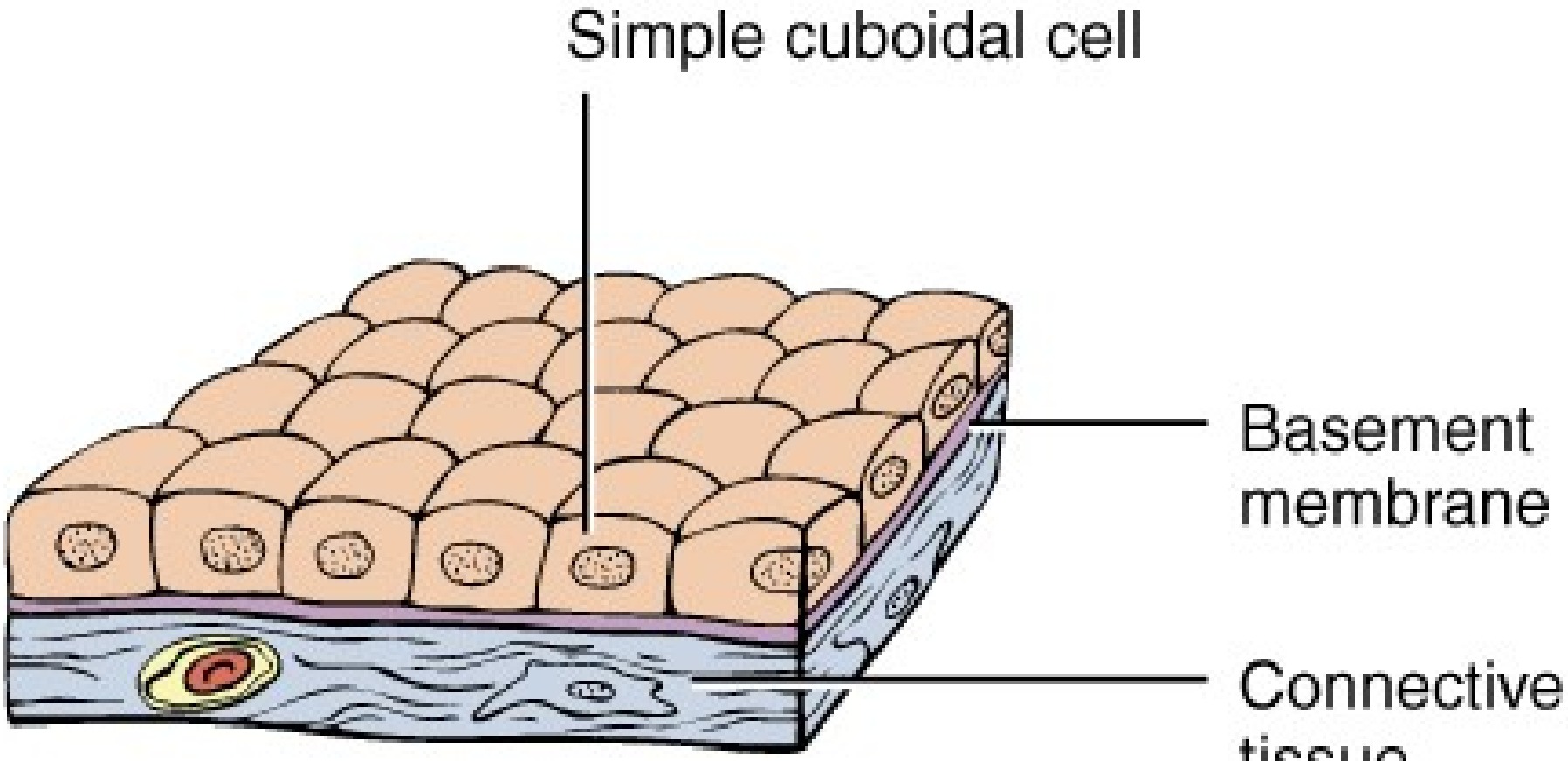
Simple squamous epithelium

SQUAMOUS

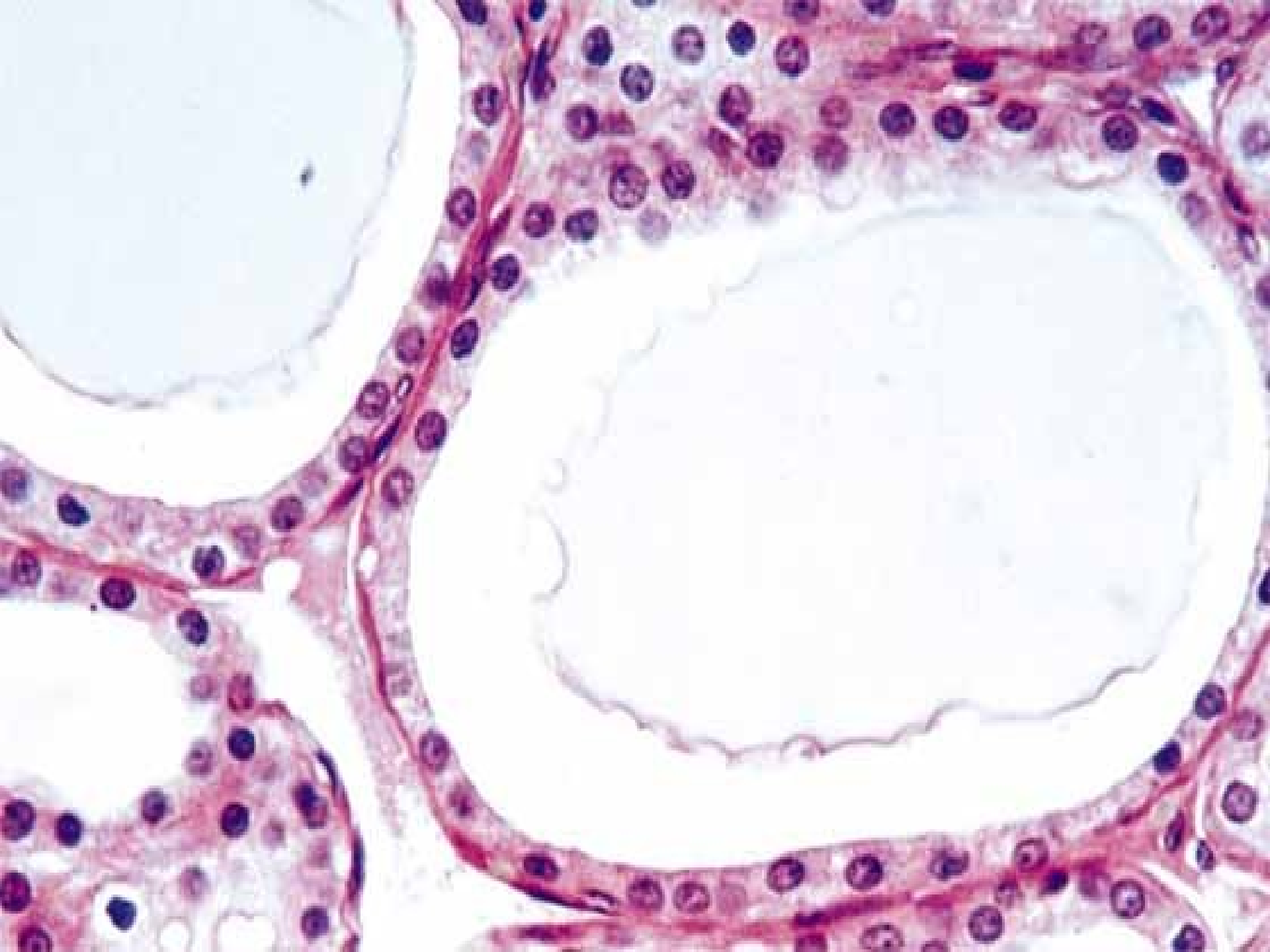


Simple *Cuboidal* Epithelium

- *Simple cuboidal epithelium* consists of a simple layer of cube-shaped cells and performs the functions of secretion and absorption (Table 4.1B).



Simple cuboidal epithelium



Simple Columnar Epithelium

- *Simple columnar epithelium* consists of a single layer of rectangular cells and can exist in two forms:
  - **nonciliated** simple columnar epithelium, and
  - **ciliated** simple columnar epithelium.

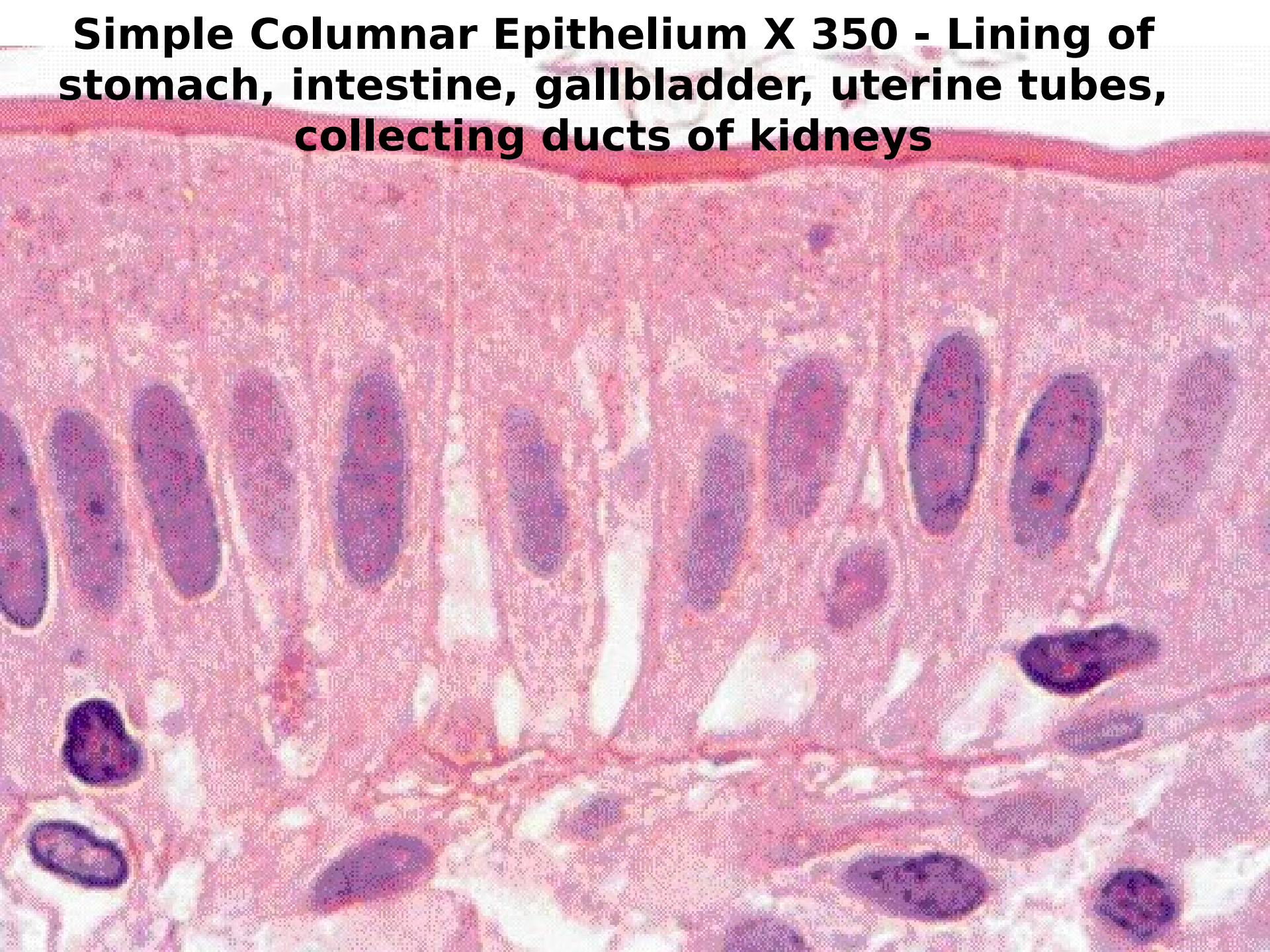
Nonciliated Simple Columnar Epithelium

- *Nonciliated simple columnar epithelium* contains **microvilli** (Fig. 3.2) to increase surface are and the rate of absorption and goblet cells that secrete mucus (Table 4.1C).

Ciliated Simple Columnar Epithelium

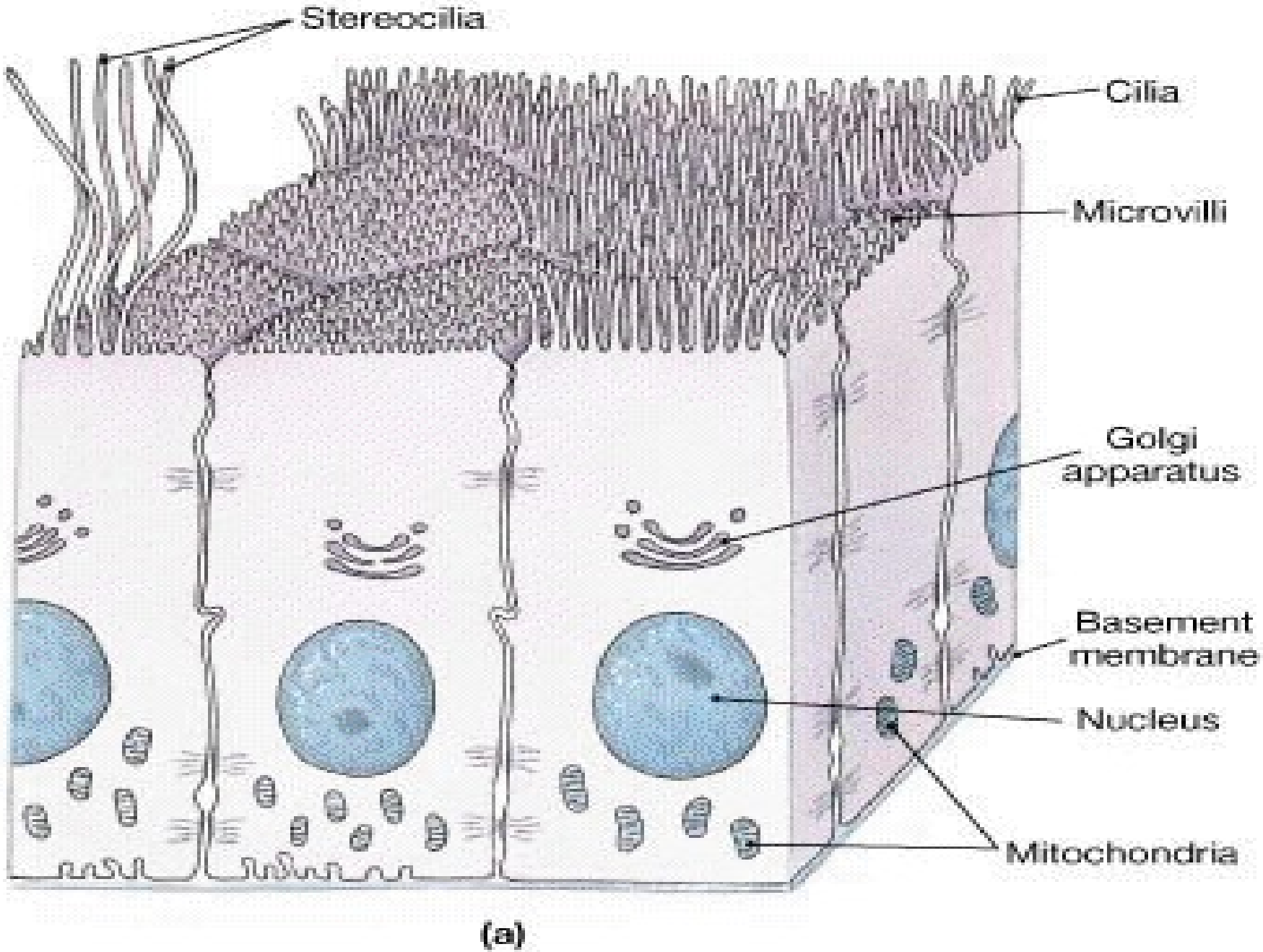
- *Ciliated simple columnar epithelium* (Table 4.1D) contains cells with **cilia**, motile, hair-like processes that help to move fluids or particles along a surface.

Simple Columnar Epithelium X 350 - Lining of stomach, intestine, gallbladder, uterine tubes, collecting ducts of kidneys



COLUMNAR

- Some have stereocilia
- May be ciliated
- Some microvilli (brush border)
- Secretory
- Absorption


Stereocilia
Cilia
Microvilli
Golgi apparatus
Basement membrane
Nucleus
Mitochondria
(a)

Stratified Epithelium

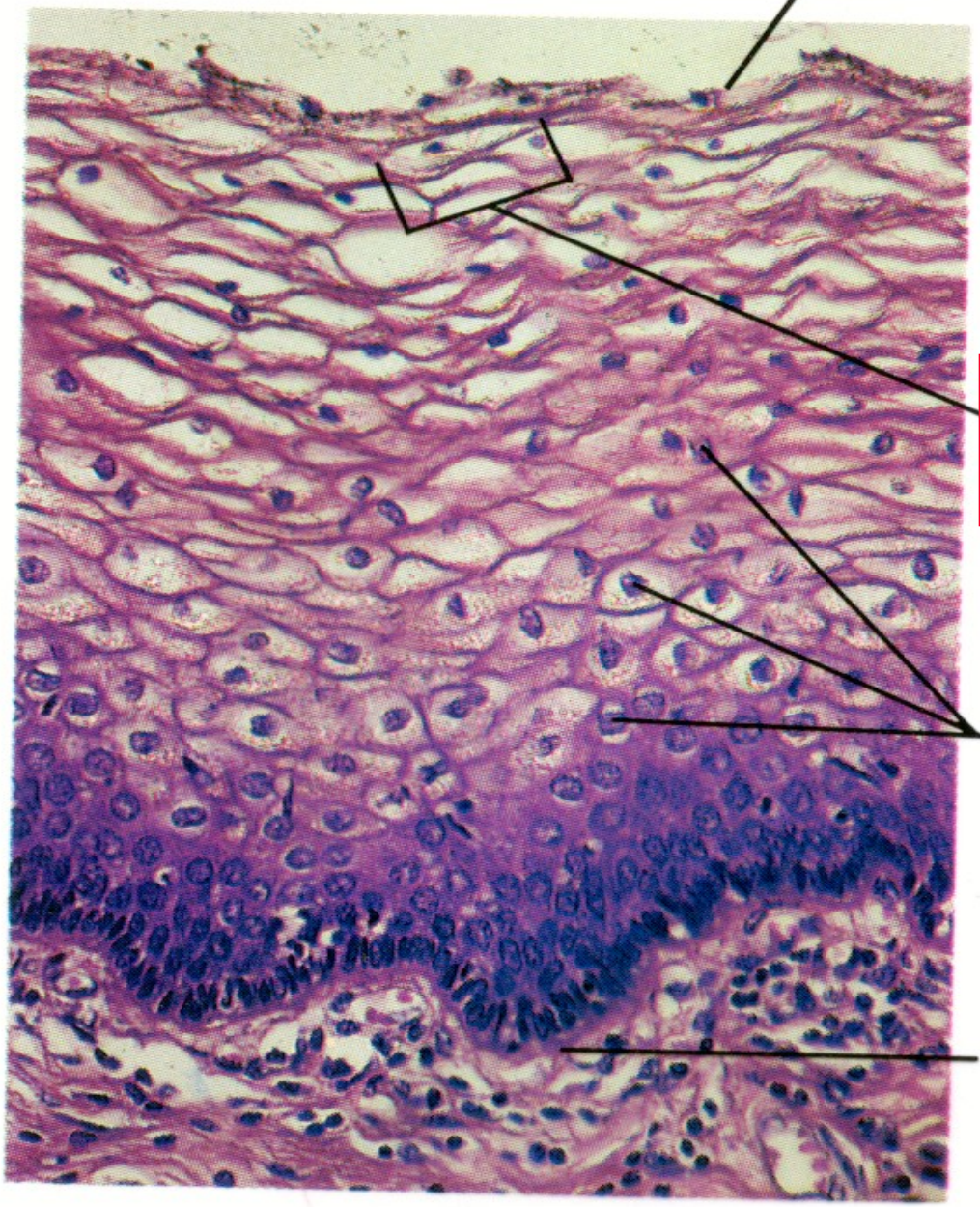
- Epithelia have at least two layers of cells.This is a more durable and protective tissue.
- The name of the specific kind of stratified epithelium depends on the shape of the surface cells.

Stratified Squamous Epithelium

- *Stratified Squamous Epithelium* consists of several layers of cells in which the top layer of cells is flat and the deeper layers of cells vary in shape from cuboidal to columnar.
  - The basal cells replicate by mitosis and ultimately work their way to the surface.

Stratified Squamous Epithelium

- In *keratinized stratified squamous epithelium*, a tough layer of keratin (a protein resistant to friction and repels bacteria) is deposited in the surface cells.
- *Nonkeratinized stratified squamous epithelium* does not contain keratin and remains moist.


Free surface
Moist stratified squamous epithelial cell
Nuclei
Basement membrane

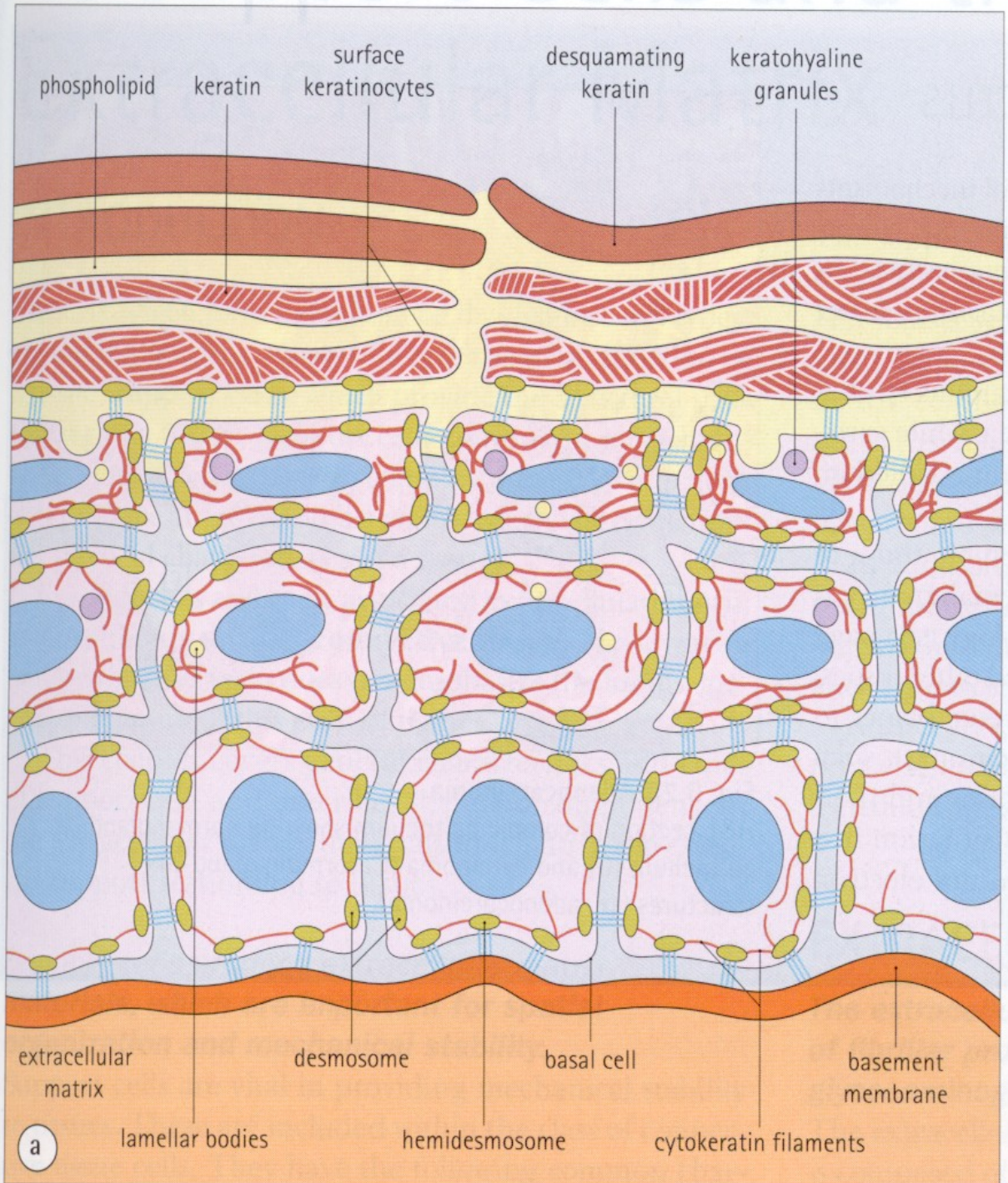
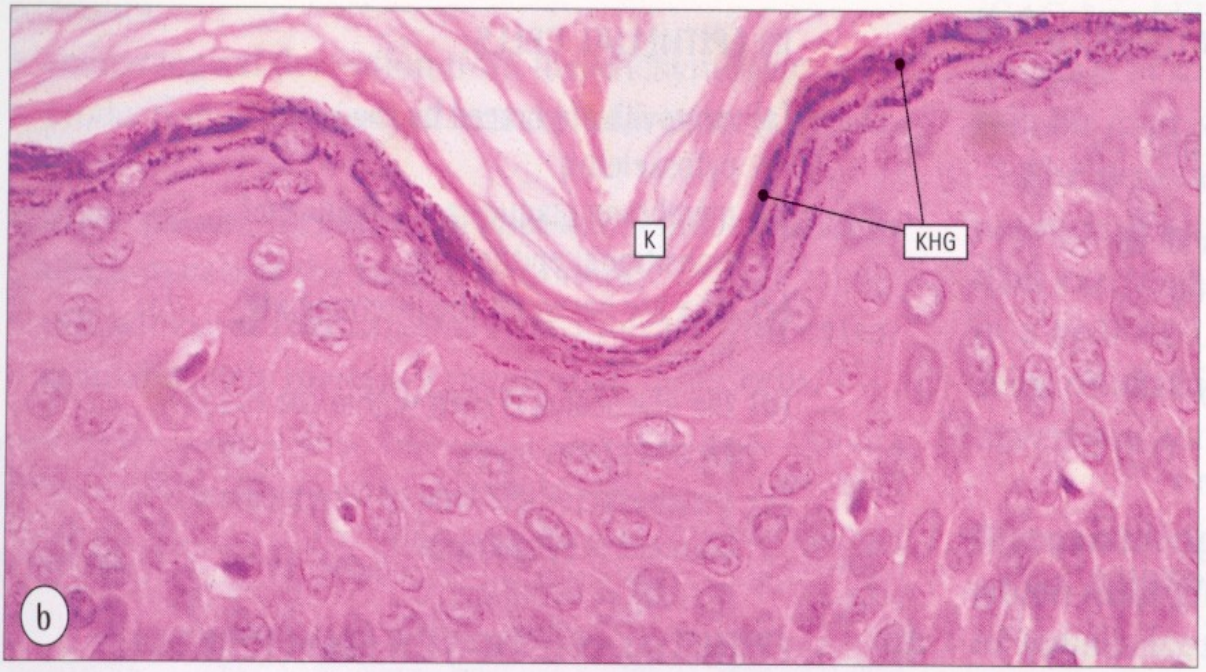
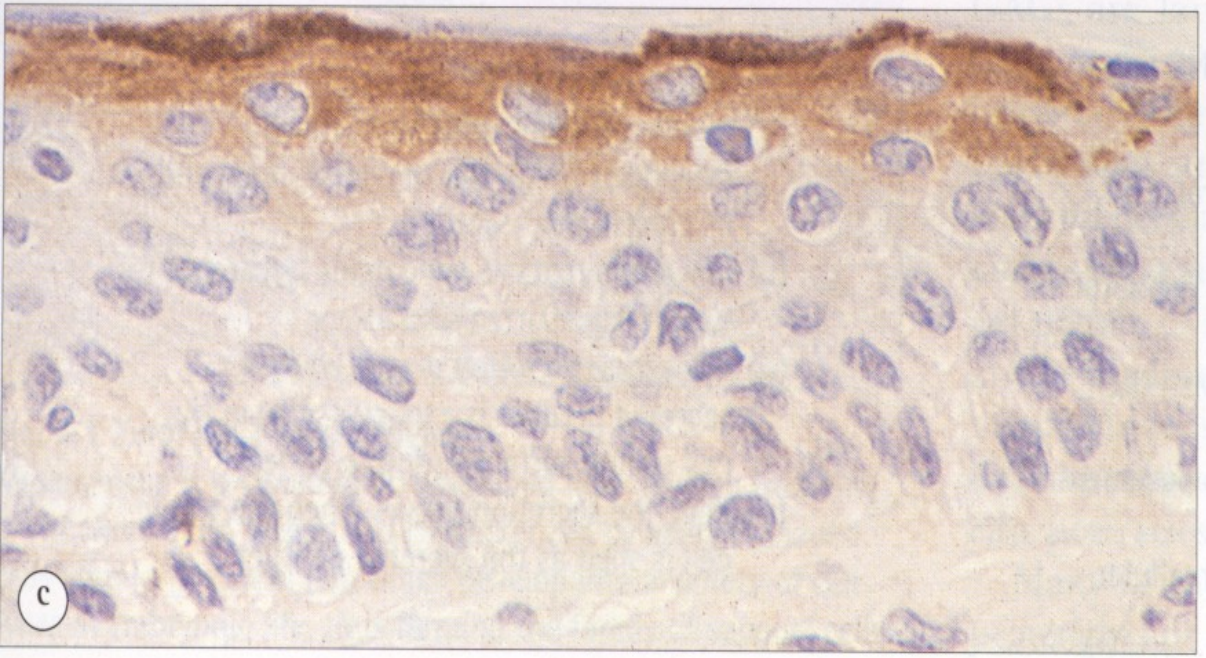


Fig. 3.27 Keratinization.
(a) Basal cells of keratinizing squamous epithelium are anchored by hemidesmosomes and desmosomes to basement membrane and adjacent cells, and contain abundant cytokeratin intermediate filaments (tonofibrils). As the cells differentiate and move up the stratified epithelium they remain tightly bound by desmosomal junctions, but the cytokeratin proteins change to higher molecular weight forms and the cells develop lamellar bodies. Lamellar bodies are membrane-bound granules containing phospholipids which are secreted by exocytosis into the extracellular space and form a lamellar sheet between cells in the upper epithelium. Cells in the upper part of the epithelium express genes coding for a variety of specialized proteins which interact with the cytokeratin filaments and the cell membrane to produce a resilient and mechanically robust compact mass (**keratin**). Small granules (**keratohyaline granules**) contain some of these specialized proteins. A prominent protein (**involucrin**) associates with and thickens the cell membrane.



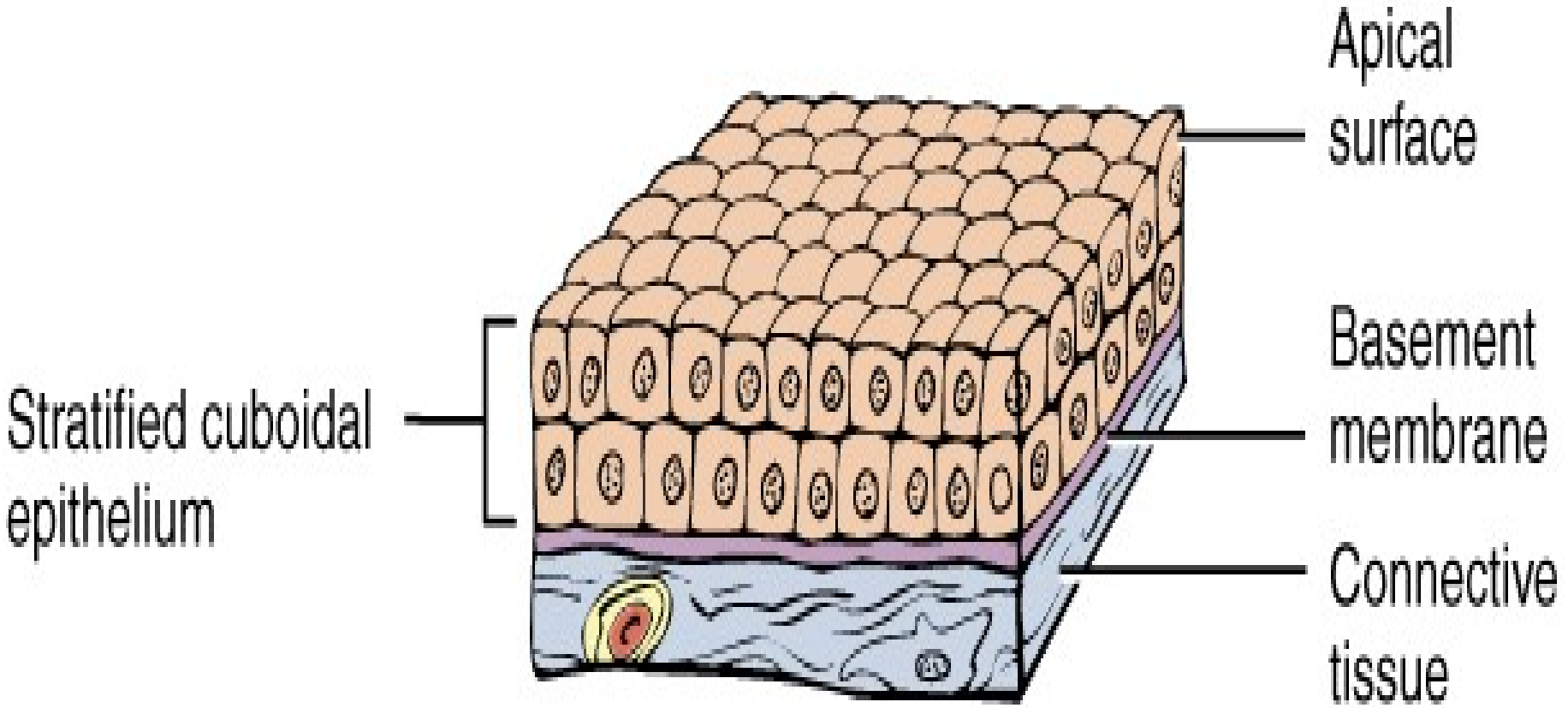
(b) H&E section of keratinized squamous epithelium. Note the purplish keratohyaline granules (KHG) and the absence of nuclei in the surface keratin layer (K).



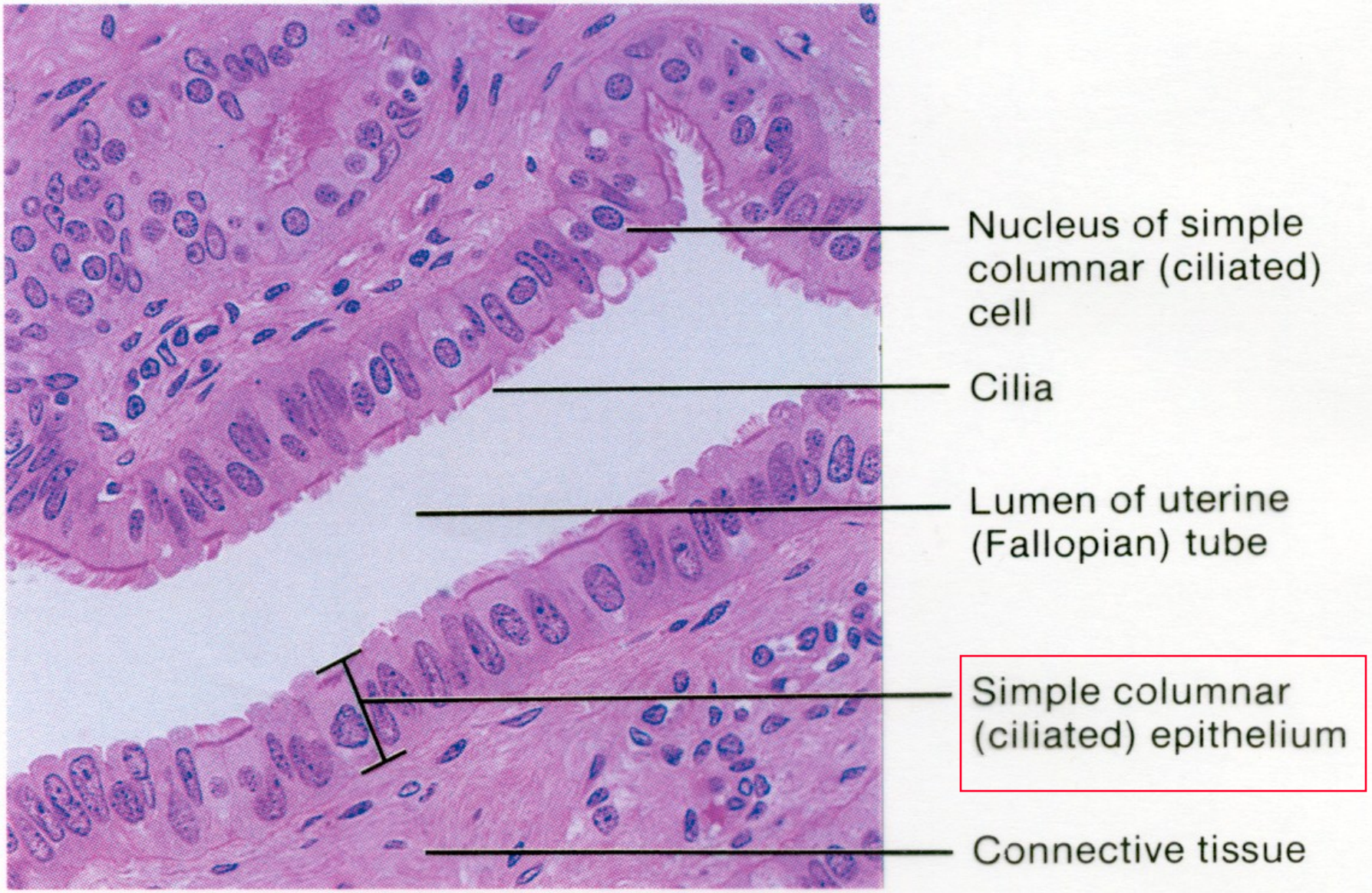
(c) Keratinizing squamous epithelium stained to show involucrin (brown), which is only present in the upper keratinizing part of the epithelium.

Stratified Cuboidal Epithelium

- *Stratified cuboidal epithelium* is a rare tissue consisting of two or more layers of cube-shaped cells whose function is mainly protective.



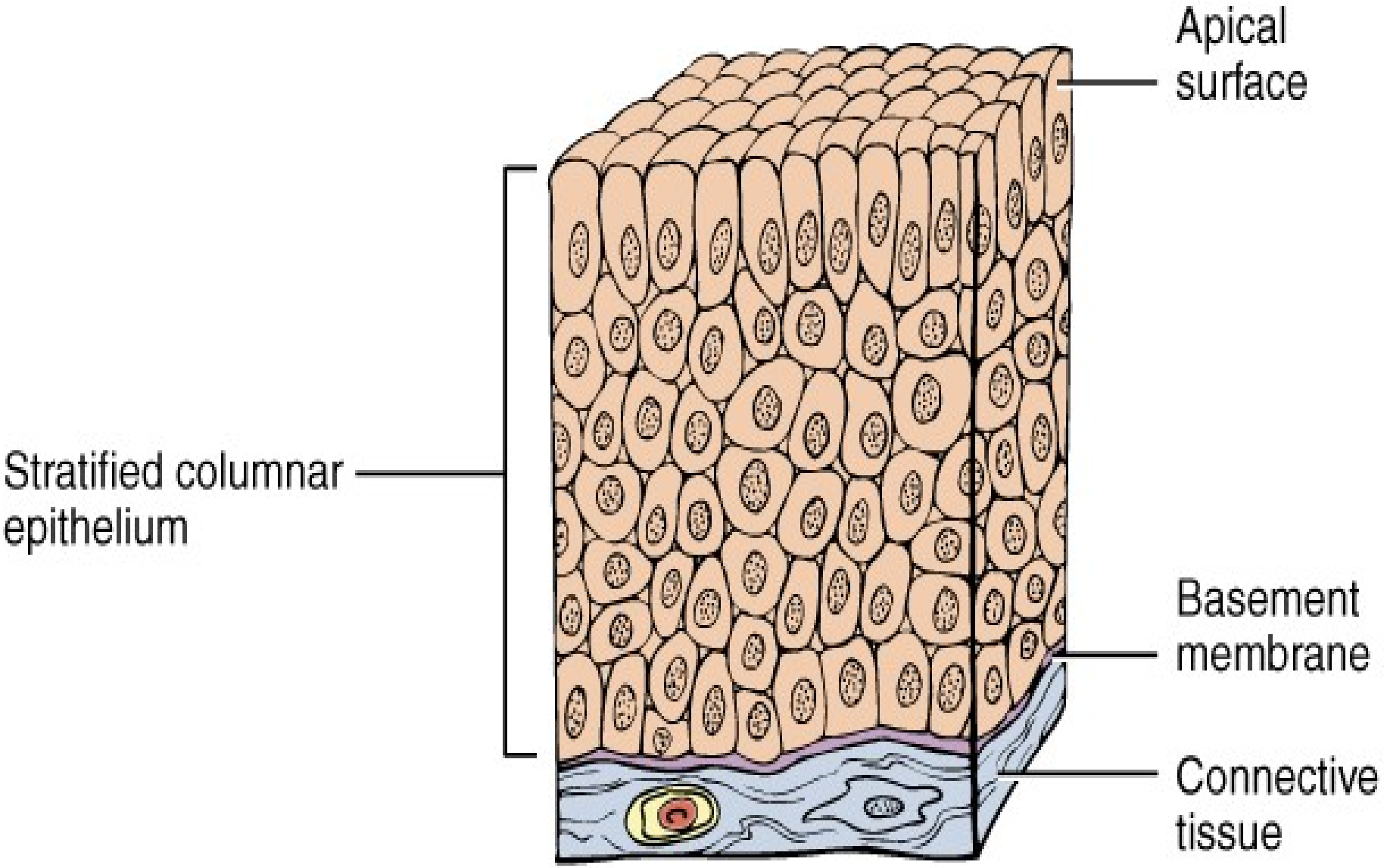
Stratified cuboidal epithelium



Sectional view of uterine (Fallopian) tube
(100 ×)

Stratified Columnar Epithelium

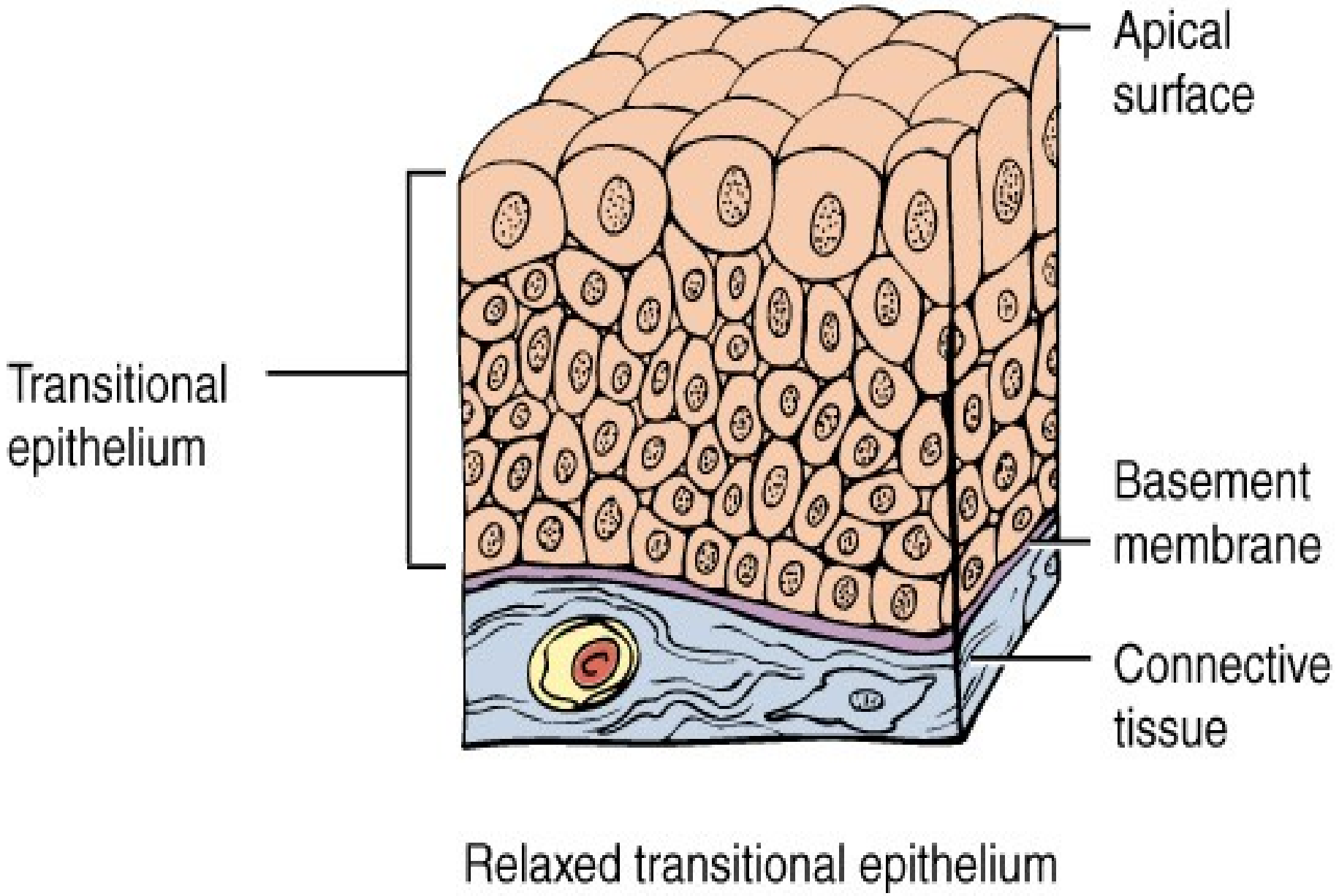
- *Stratified columnar epithelium* consists of several layers of cells of which only the top layer is columnar.
- It is somewhat rare and functions in protection and secretion.



Stratified columnar epithelium

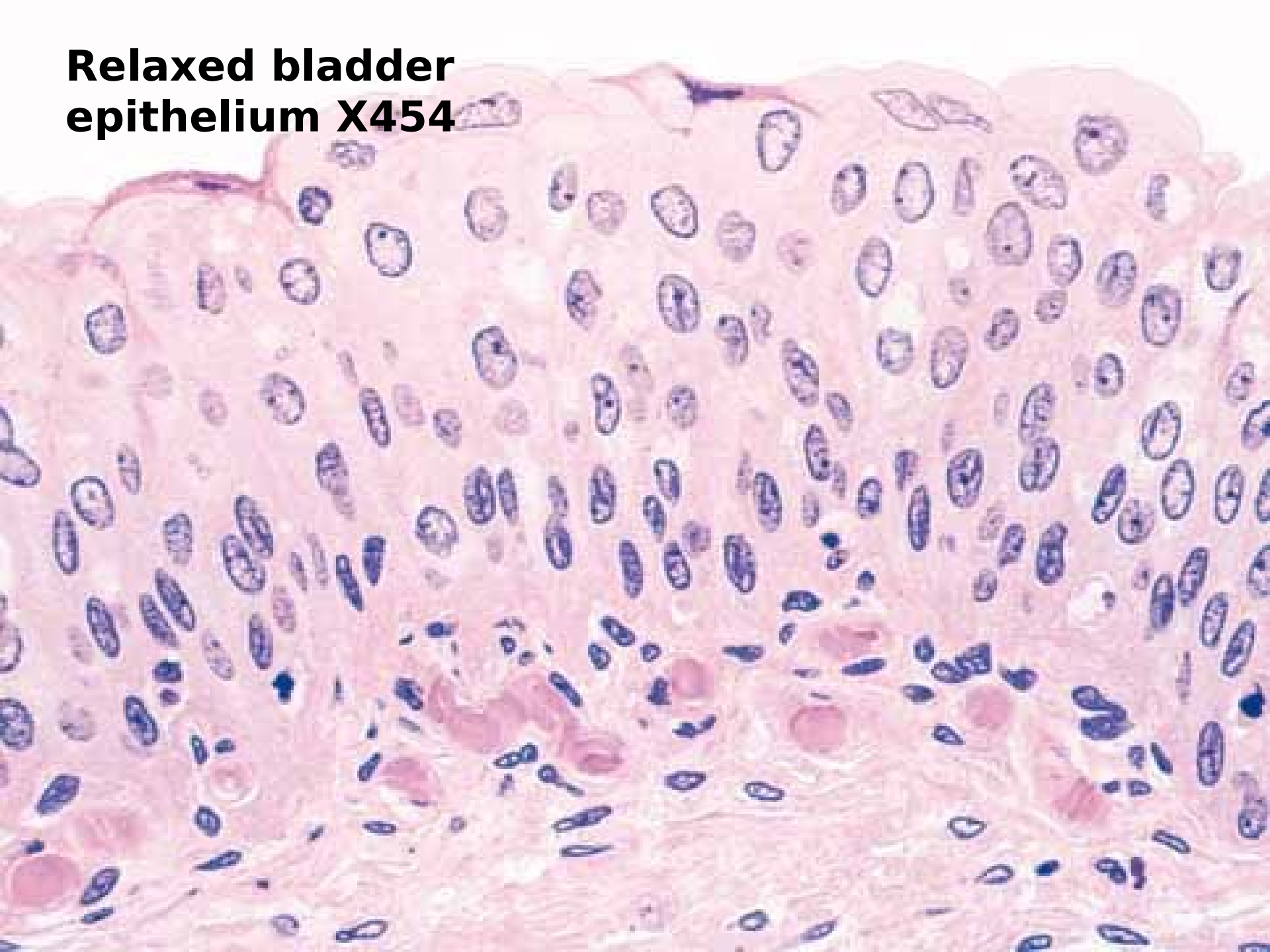
Transitional Epithelium

- *Transitional Epithelium* consists of several layers of cells whose appearance is variable.
  - It is capable of stretching and thus permits distention of an organ.
  - It lines the urinary bladder and portions of the ureters and the urethra.

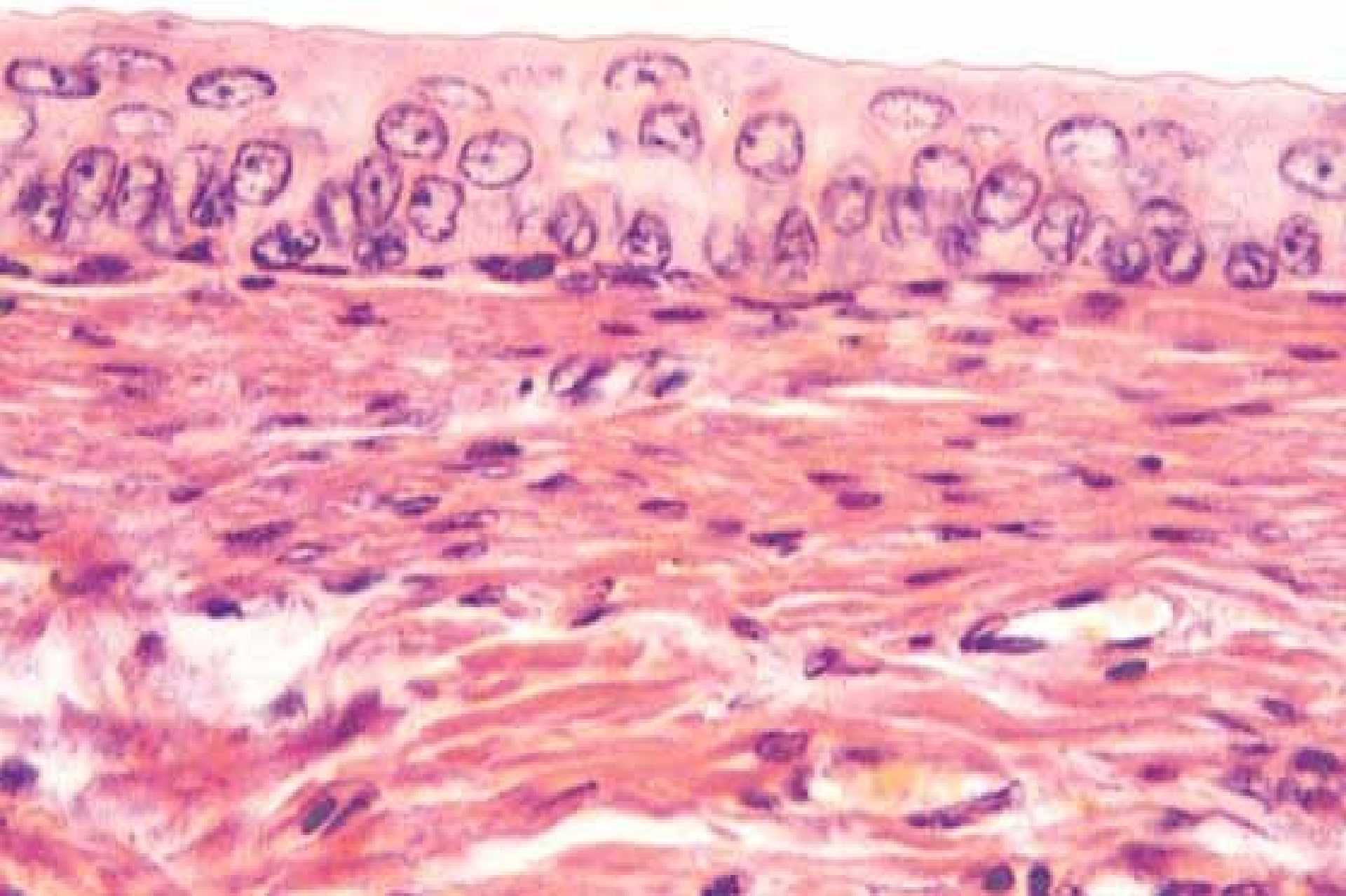


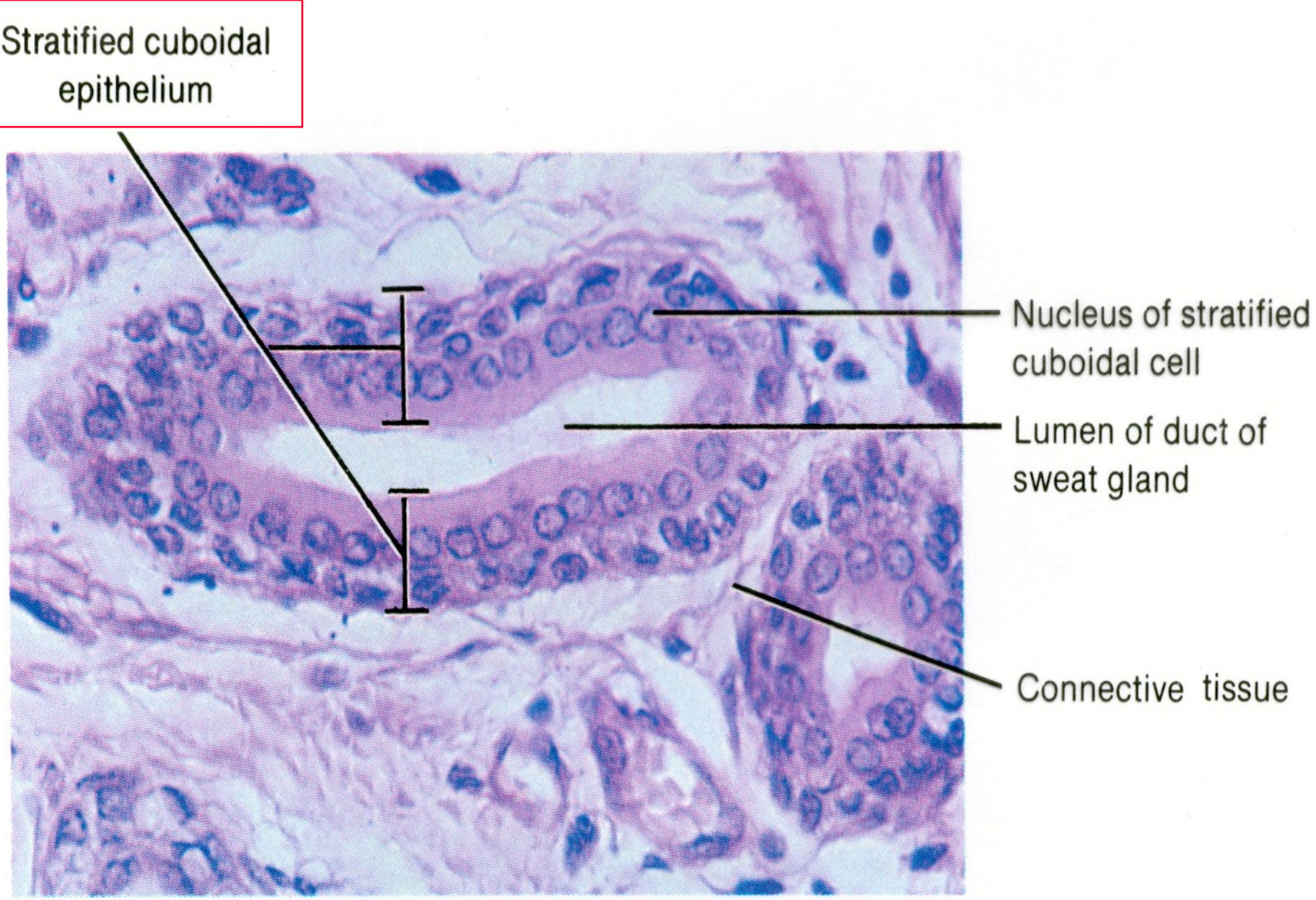
Relaxed transitional epithelium

Relaxed bladder epithelium X454

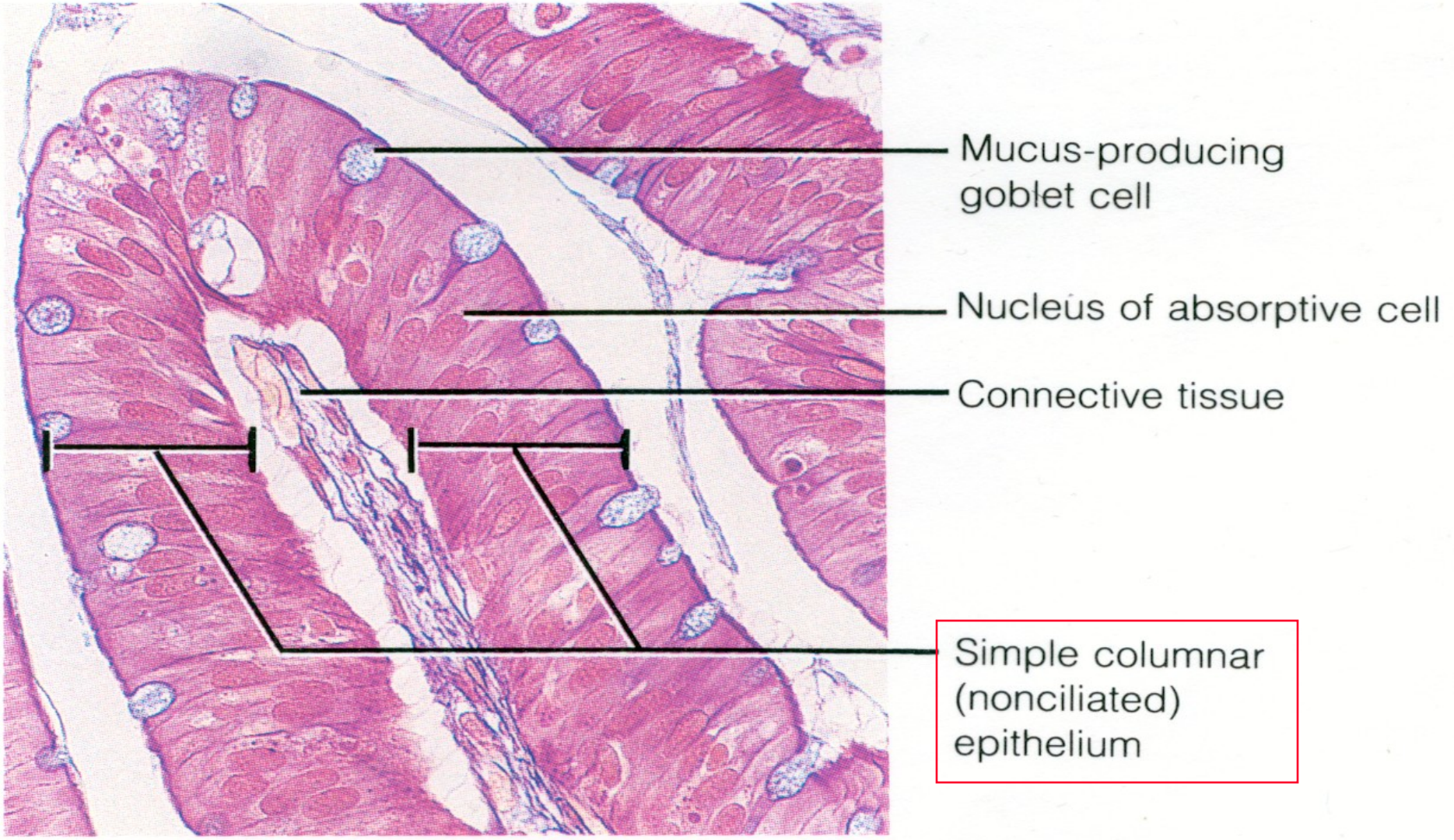


Full Bladder





Sectional view of the duct of a sweat gland (450x)



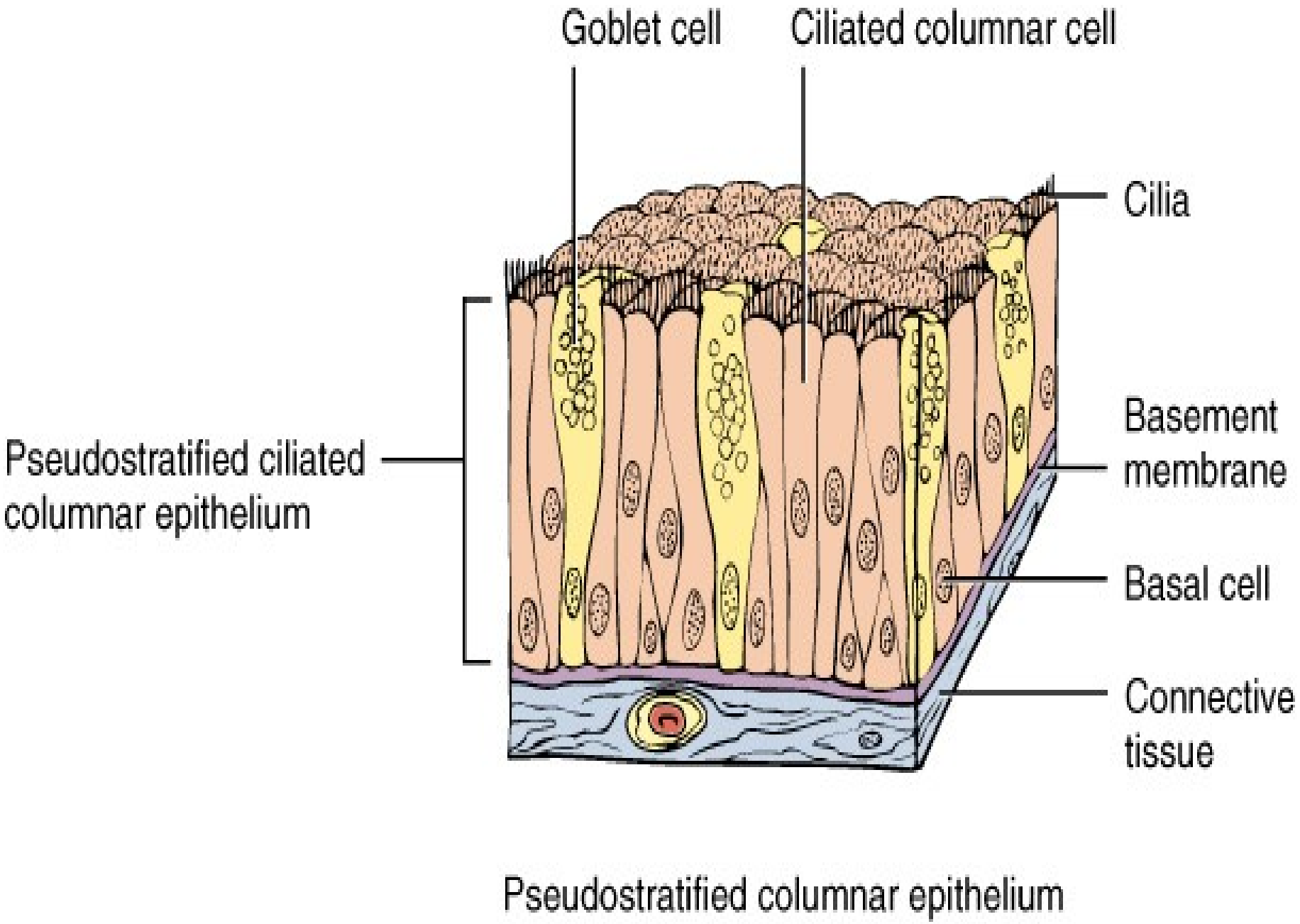
Sectional view of epithelium from the lining of small intestine (140x)

Pseudostratified Epithelium

- *Pseudostratified epithelium* has only one layer but gives the appearance of many.
  - All cells are attached to the basement membrane but some do not reach the apical surface.

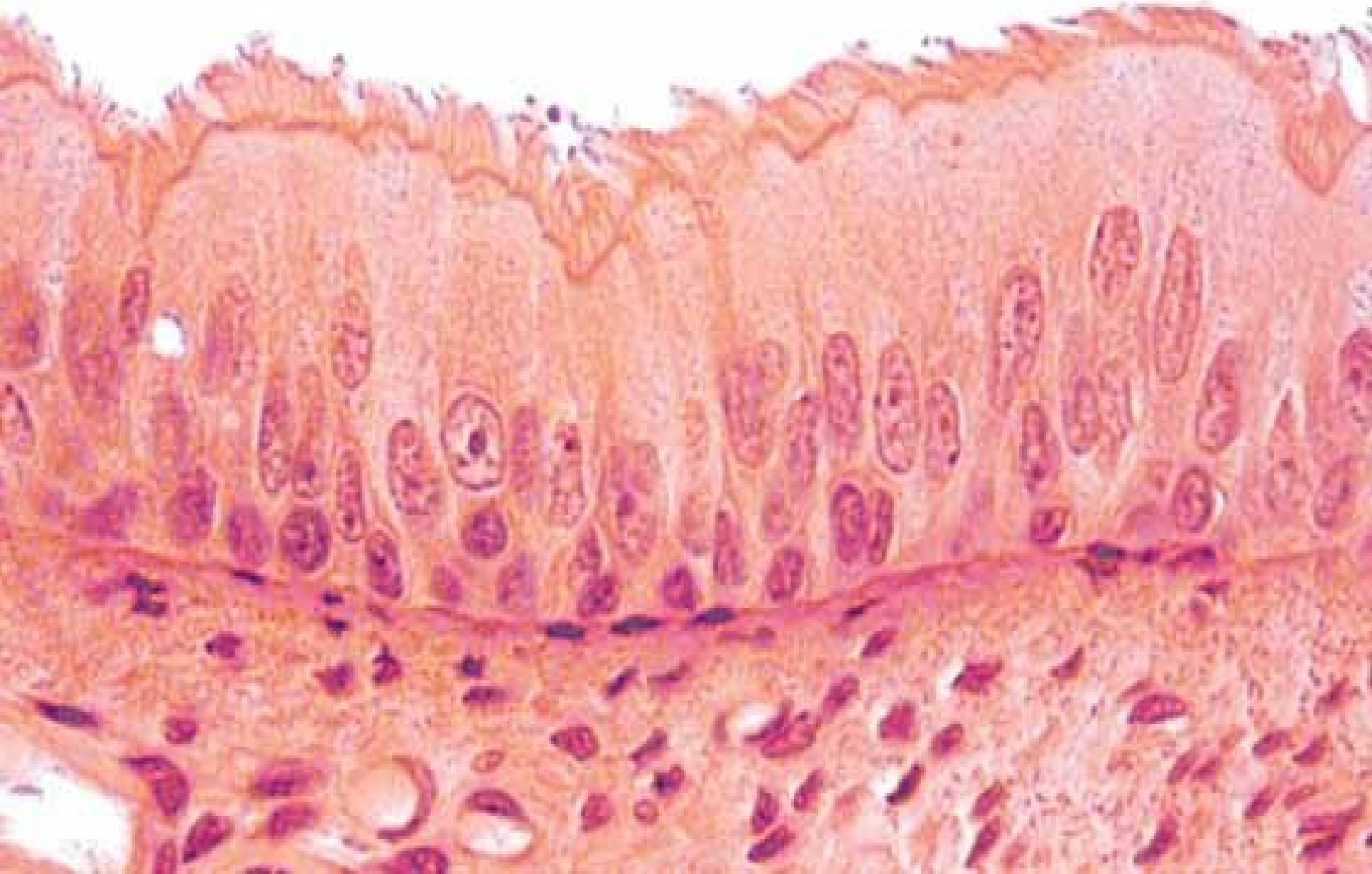
Pseudostratified Epithelium

- In *pseudostratified ciliated columnar epithelium*, the cells that reach the surface either secrete mucus (goblet cells) or bear cilia that sweep away mucus and trapped foreign particles.
- *Pseudostratified nonciliated columnar epithelium* contains no cilia or goblet cells.



Pseudostratified columnar epithelium

Pseudostratified Ciliated Columnar Epithelium X 251 -Lining of Trachea & Bronchi



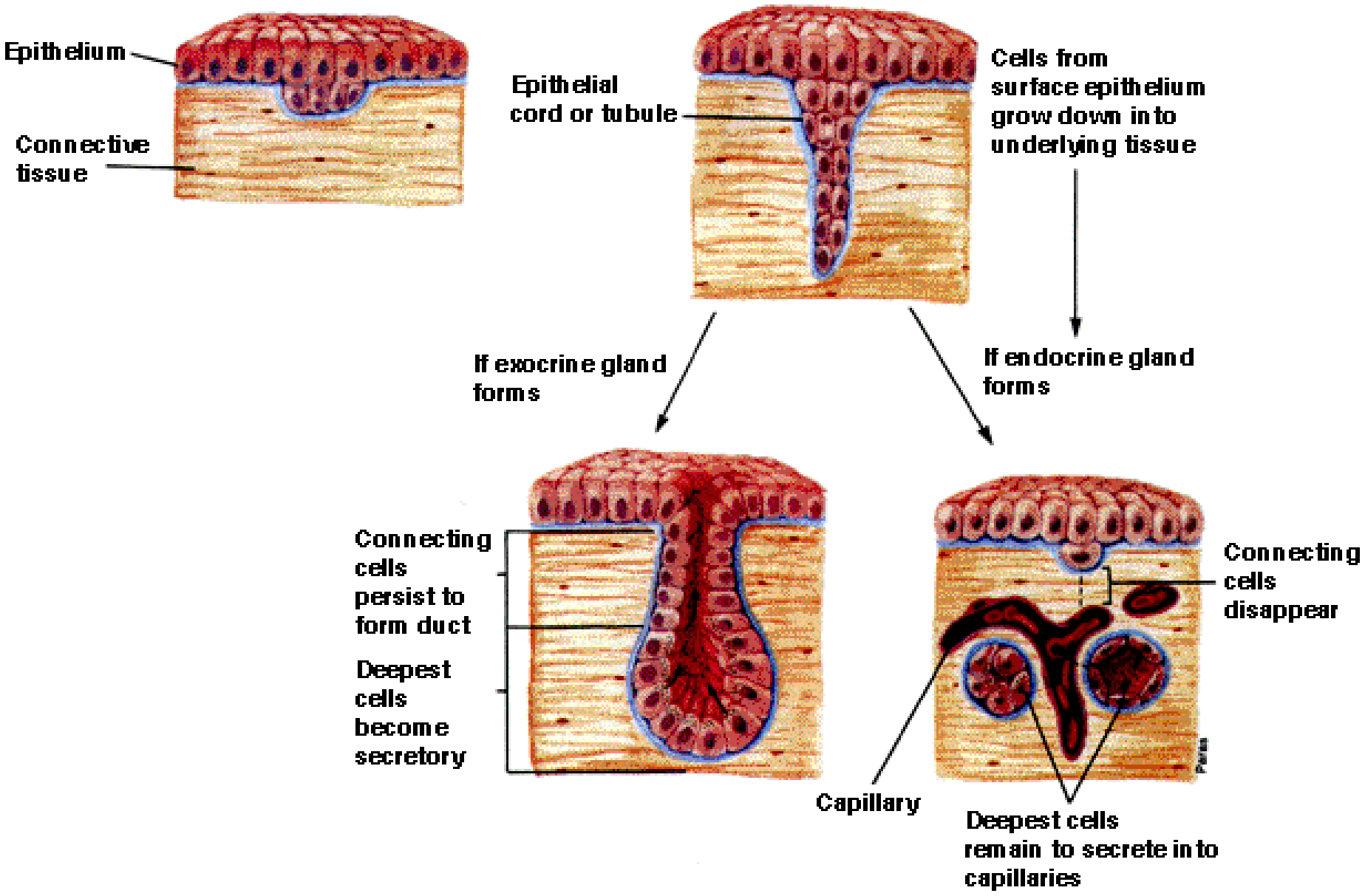
GLANDS

- Unicellular or multicellular
- Secrete into:
  - Ducts
  - Surface
  - Blood
- Exocrine *or* endocrine

GLANDULAR EPITHELIUM

- Epithelial cells embedded within deeper lying tissues.
- Designed specifically for secretion of a substance onto the cell surface or lumen of an internal organ.

Formation of Exocrine and Endocrine Glands. Figure 1.14



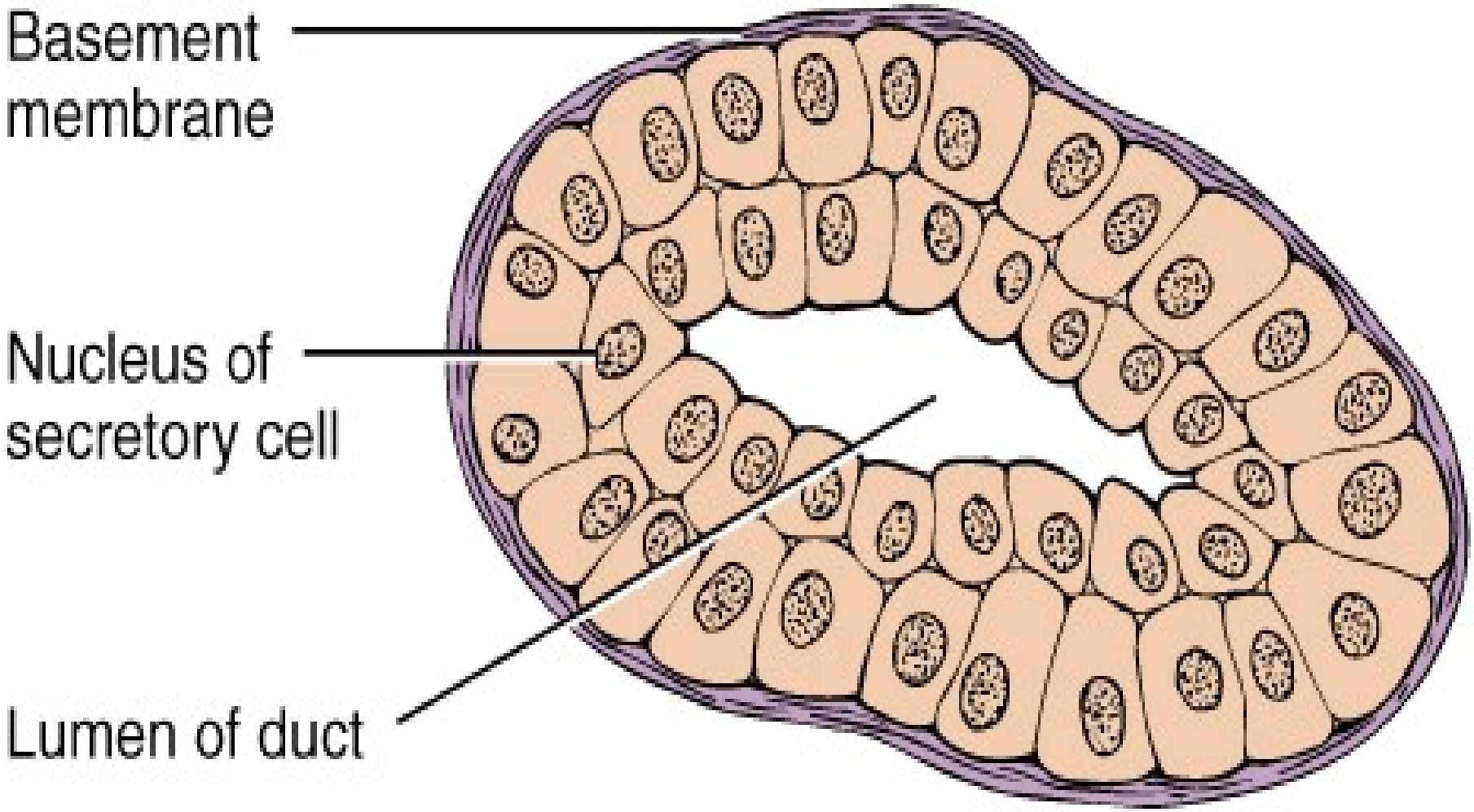


Diagram of sweat gland

Glandular Epithelium

- A *gland* is a single cell or a mass of epithelial cells adapted for secretion.
- *Endocrine glands* are ductless; their secretory products (hormones) enter the extracellular fluid and diffuse into the blood.

•4-9

–. *Exocrine glands* (sweat, oil, and digestive glands) secrete their products into ducts that empty at the surface of covering and lining epithelium or directly onto a free surface (Table 4.1K).

•4. Structural Classification of Exocrine Glands

•. Unicellular glands are single-celled, such as the goblet cell.

•Multicellular glands are composed of cells that form a distinctive microscopic structure or macroscopic organ, such as sweat, oil, and salivary glands.

•) They occur in several different forms (Fig. 4.3) including tubular glands, acinar glands, tubuloacinar glands, simple glands, and compound glands.

• Combining the shapes of the secretory portion with the degree of branching of the duct gives the structural classification for multicellular glands.

–. Functional classification of exocrine glands is based on whether a

– a secretion is a product of a cell or consists of entire or partial glandular

– cells themselves.

•) *Holocrine glands* accumulate the secretory product in the

• cytosol; when the cell dies, it and its products are discharged

• as the glandular secretion, with the discharged cell being

• replaced by a new one (Fig 4.4a).

• 4-10

•) *Merocrine glands* form the secretory products and discharge it

• by exocytosis (Fig. 4.4b).

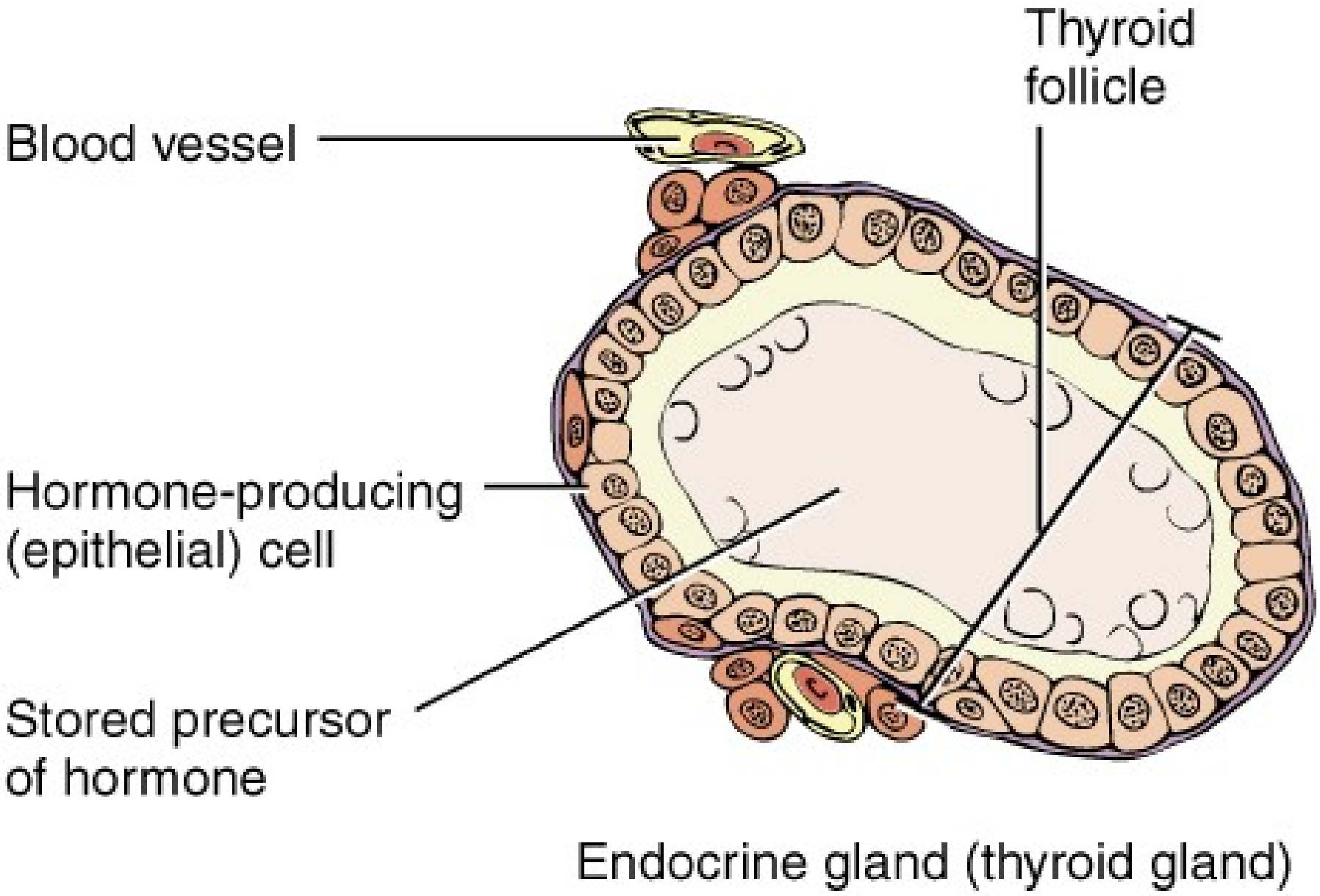
•) *Apocrine glands* accumulate their secretary product at the

• apical surface of the secreting cell; that portion then pinches off

• from the rest of the cell to form the secretion with the

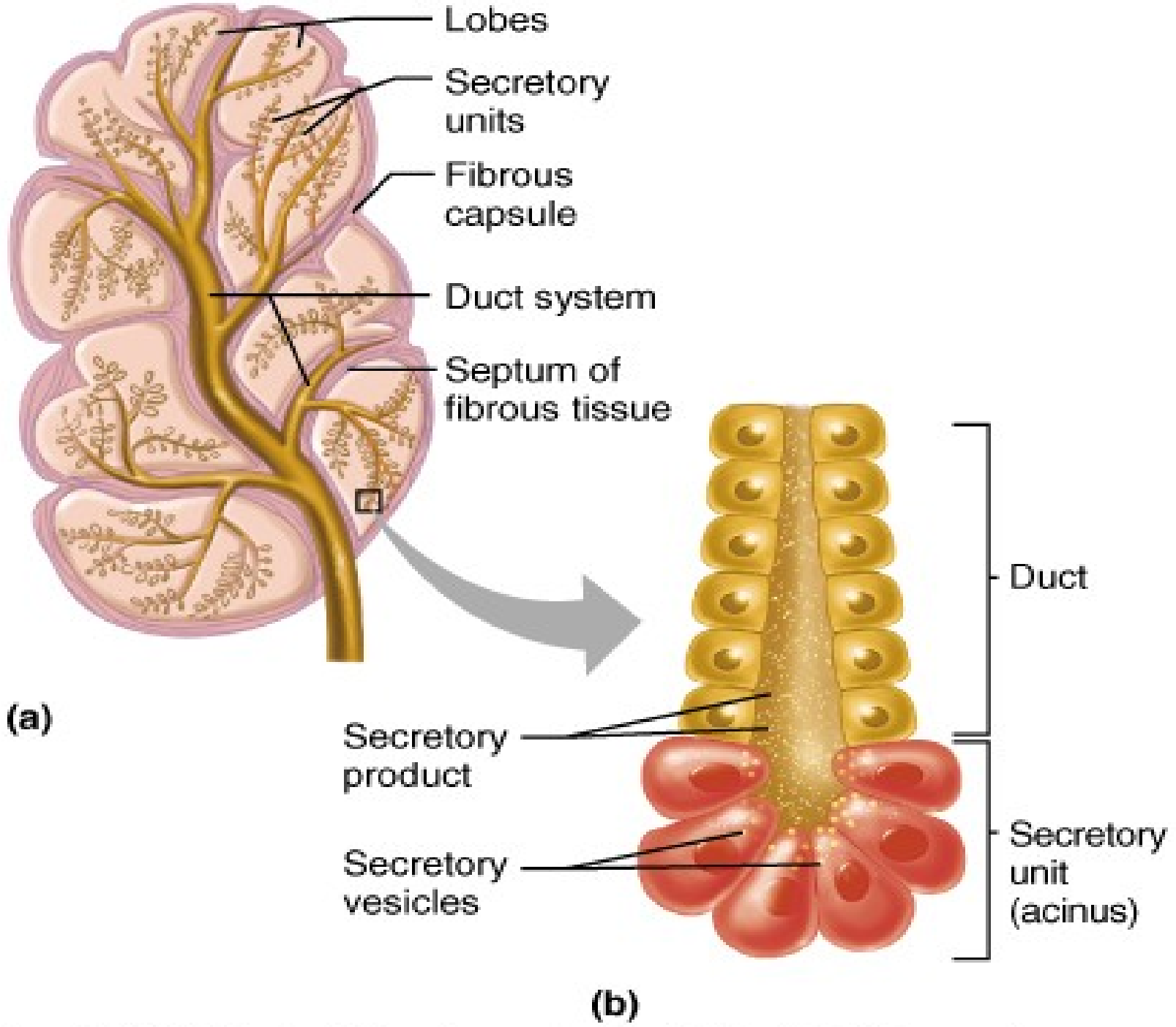
• remaining part of the cell repairing itself and repeating the

• process (Fig. 4.4c).



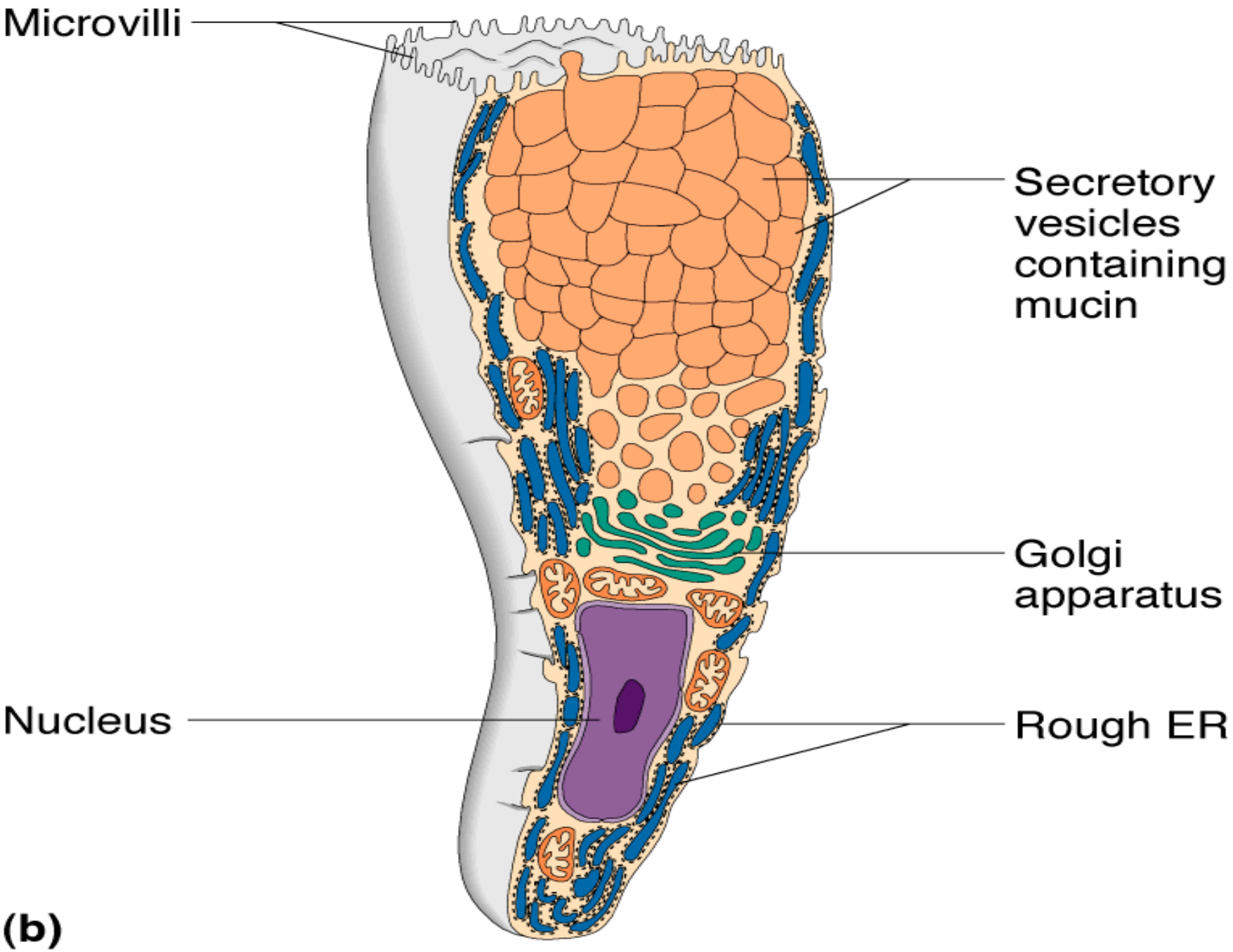
Glandular Epithelium

- ***Exocrine glands*** (sweat, oil, and digestive glands) secrete their products into ducts that empty at the surface of covering and lining epithelium or directly onto a free surface.


Lobes
Secretory units
Fibrous capsule
Duct system
Septum of fibrous tissue
(a)
Duct
Secretory product
Secretory vesicles
Secretory unit (acinus)
(b)

Structural Classification of Exocrine Glands

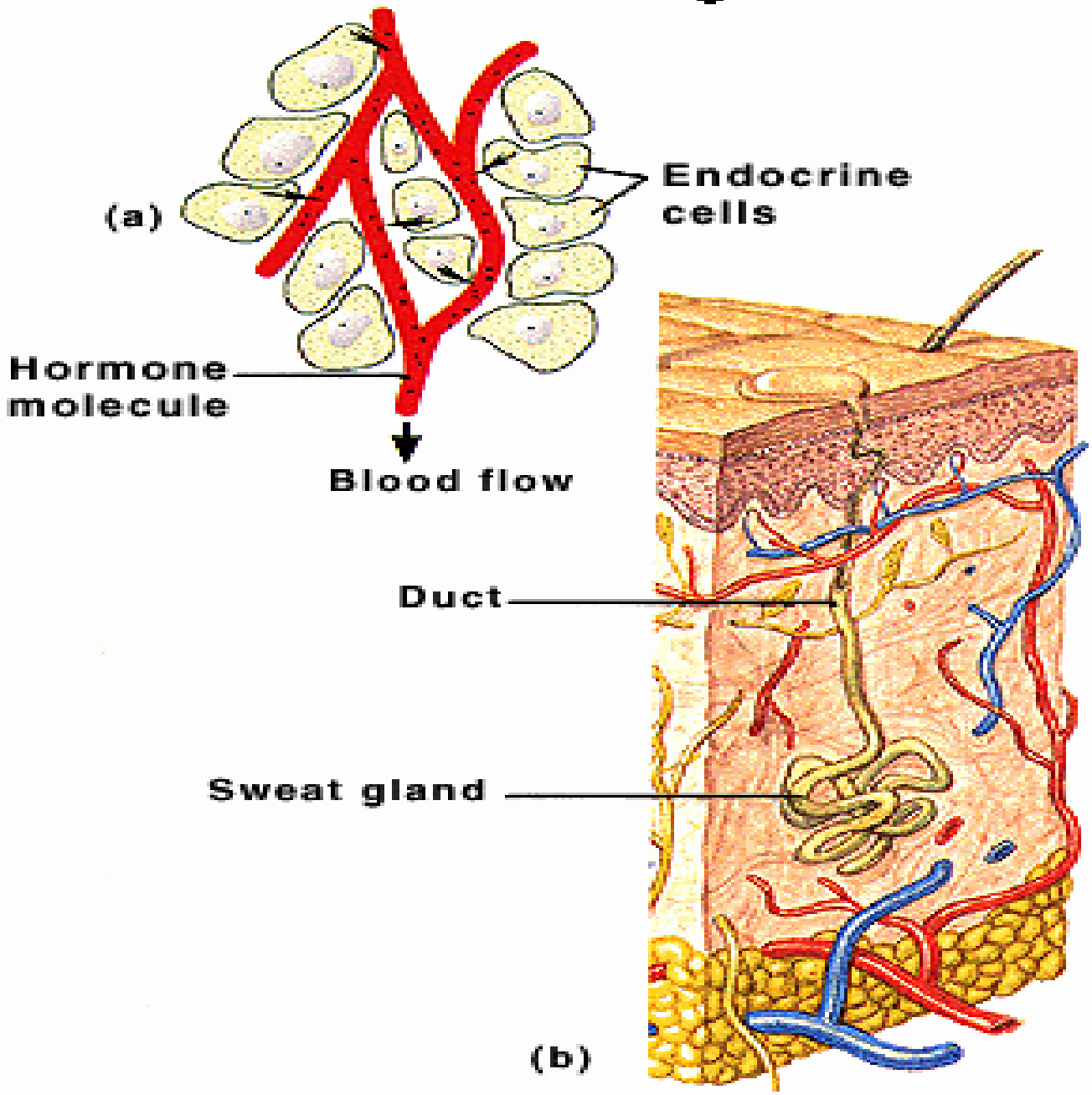
- Unicellular glands are single-celled, such as the goblet cell.
- Multicellular glands are composed of cells that form a distinctive microscopic structure or macroscopic organ, such as sweat, oil, and salivary glands.


Microvilli
Secretory vesicles containing mucin
Golgi apparatus
Nucleus
Rough ER
(b)

Structural Classification of Exocrine Glands

- They occur in several different forms including tubular glands, acinar glands, tubuloacinar glands, simple glands, and compound glands.
- Combining the shapes of the secretory portion with the degree of branching of the duct gives the structural classification for multicellular glands.

Endocrine Glands. Figure 13.1

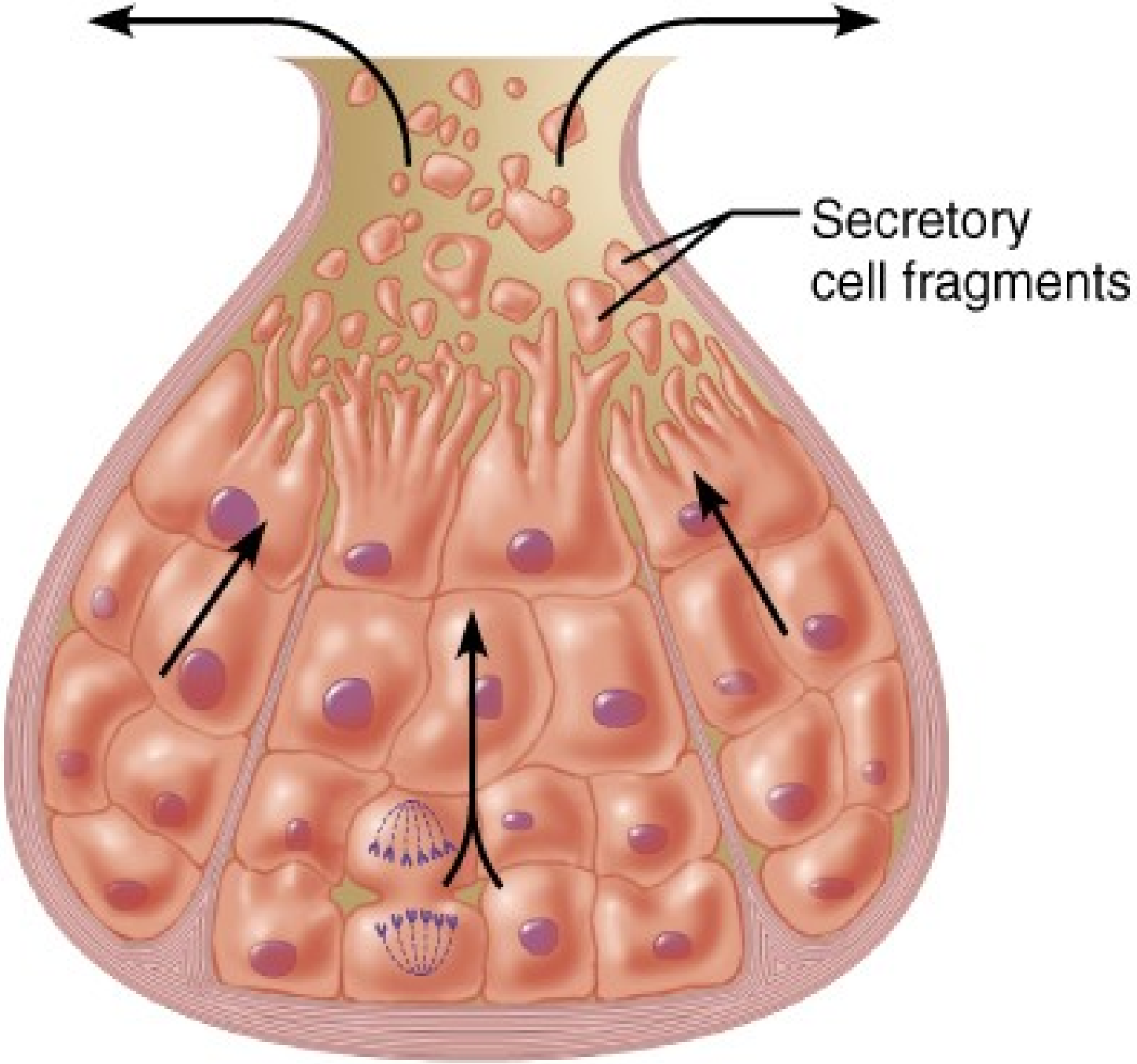


CLASSIFICATION

- Exocrine
  - Secrete to surface or lumen
  - Usually have ducts
  - Sweat, oil, mucus, enzymes
- Endocrine
  - Secrete to extracellular space
  - Diffuse to blood stream
  - Hormones

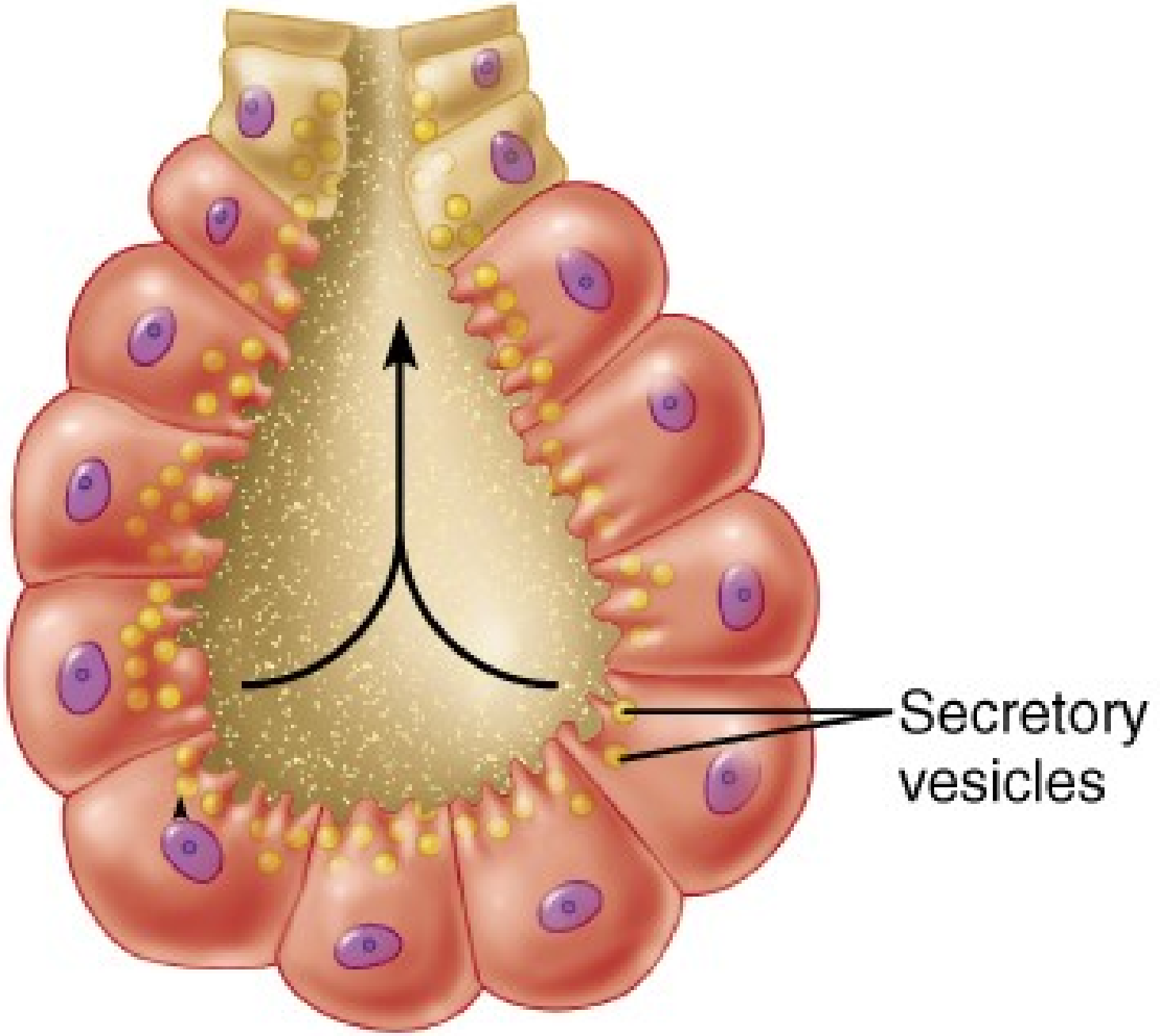
Functional Classification of Exocrine Glands

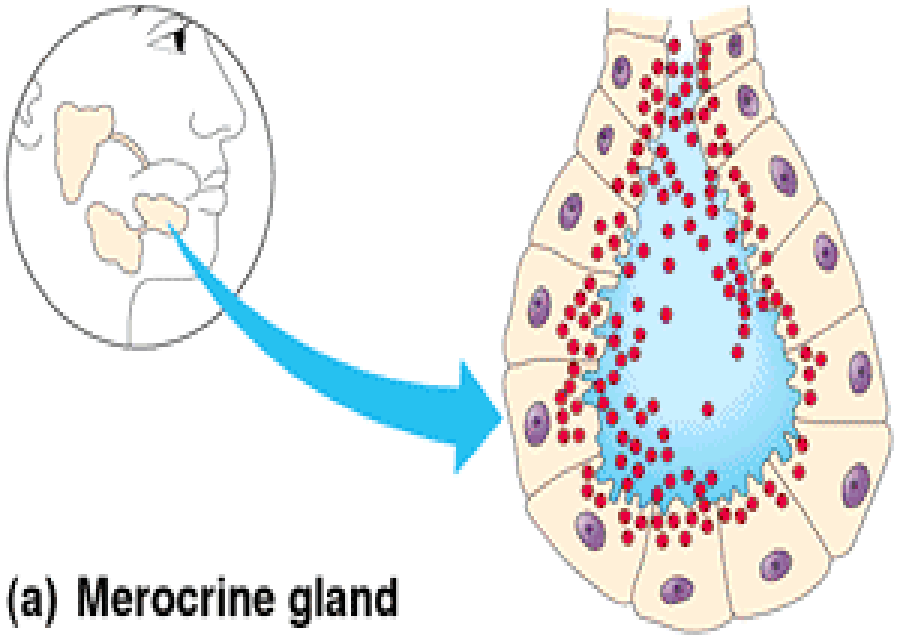
- Functional classification of exocrine glands is based on whether a secretion is a product of a cell or consists of entire or partial glandular cells themselves.
  - *Holocrine glands* accumulate the secretory product in the cytosol; when the cell dies, it and its products are discharged as the glandular secretion, with the discharged cell being replaced by a new one.


Secretory
cell fragments

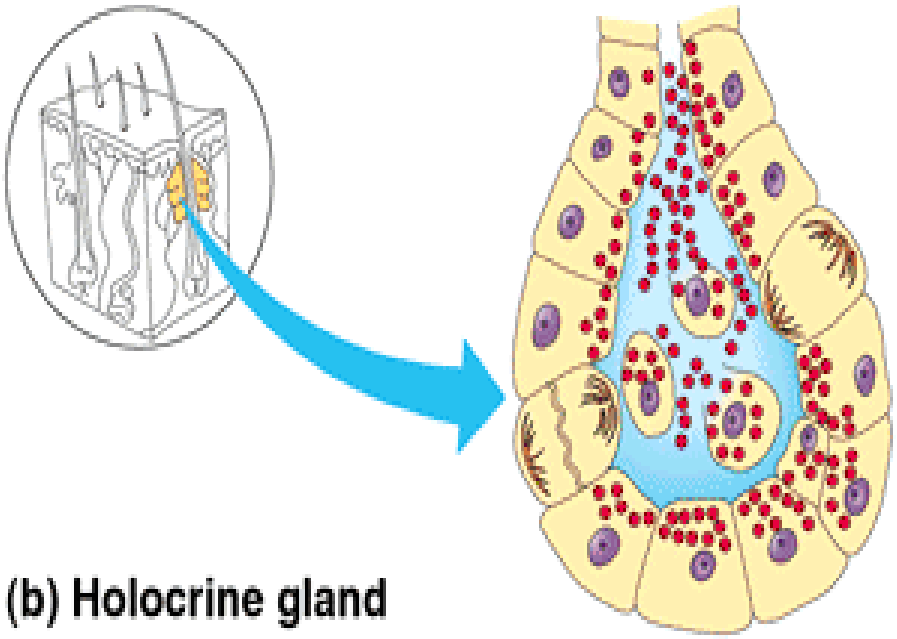
Functional Classification of Exocrine Glands

- *Merocrine glands* form the secretory products and discharge it by exocytosis.
- *Apocrine glands* accumulate their secretary product at the apical surface of the secreting cell; that portion then pinches off from the rest of the cell to form the secretion with the remaining part of the cell repairing itself and repeating the process.


Secretory
vesicles



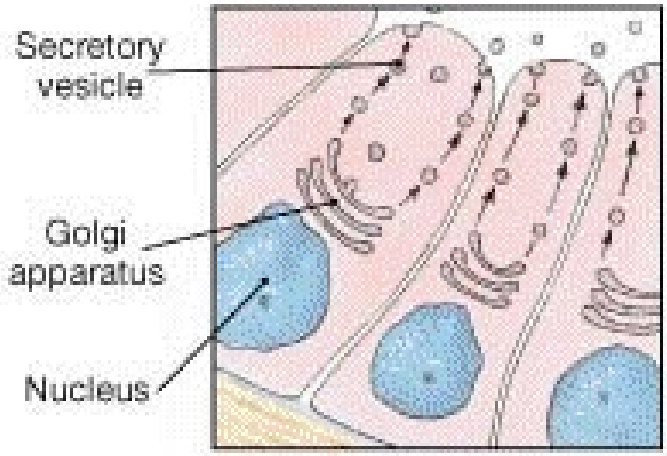
(a) Merocrine gland



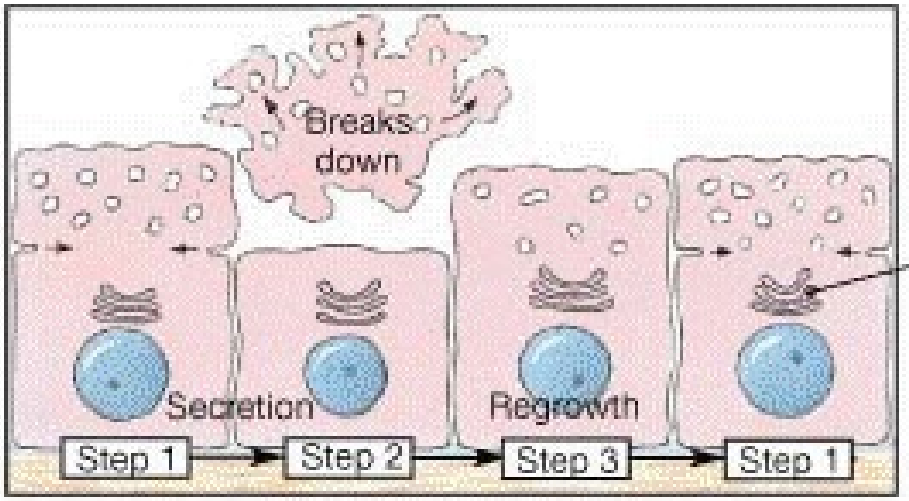
(b) Holocrine gland

EXOCRINE GLANDS

- Merocrine (most common) - Discharge secretory product; salivary glands & pancreas
- Apocrine - Apical portion discharged -questionable if humans have these
- Holocrine - Whole cell secreted - it dies & becomes the secretory product; sebaceous (oil) gland of the skin

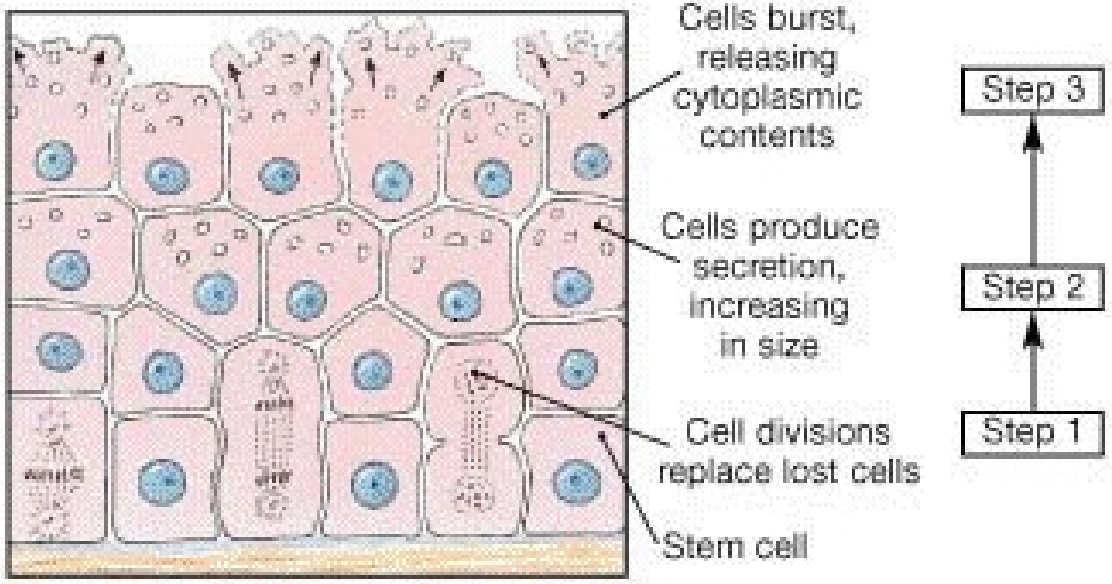


(a) Merocrine secretion

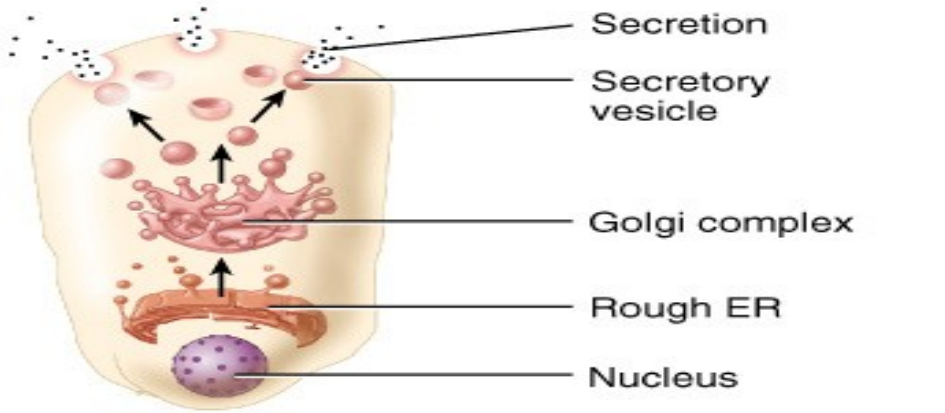


(b) Apocrine secretion

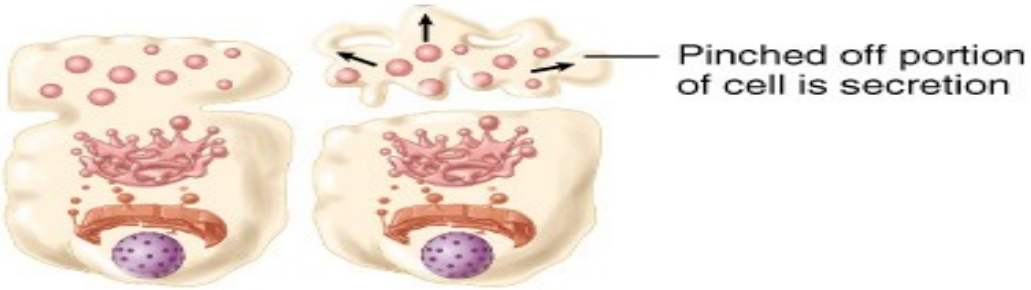
• FIGURE 4-6 Mechanisms of Glandular Secretion. **(a)** In merocrine secretion, secretory vesicles are discharged at the surface of the gland cell through exocytosis. **(b)** Apocrine secretion involves the loss of apical cytoplasm. Inclusions, secretory vesicles, and other cytoplasmic components are shed in the process. The gland cell then undergoes a period of growth and repair before it releases additional secretions. **(c)** Holocrine secretion occurs as superficial gland cells burst. Continued secretion involves the replacement of these cells through the mitotic divisions of underlying stem cells.



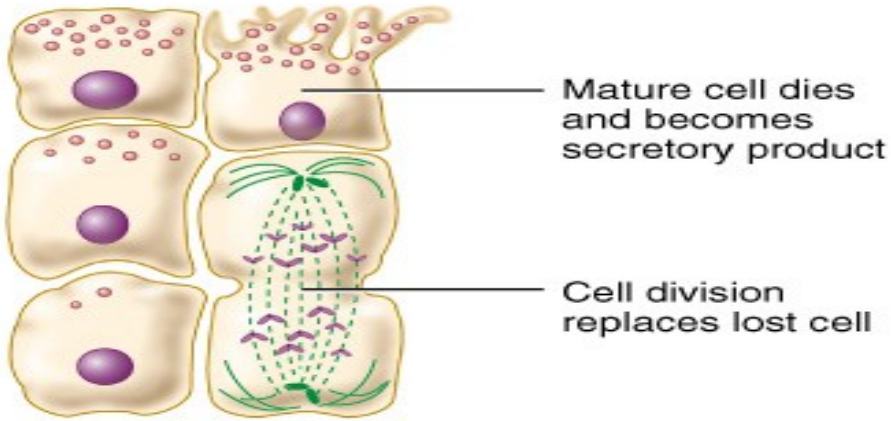
(c) Holocrine secretion



(a) Merocrine secretion

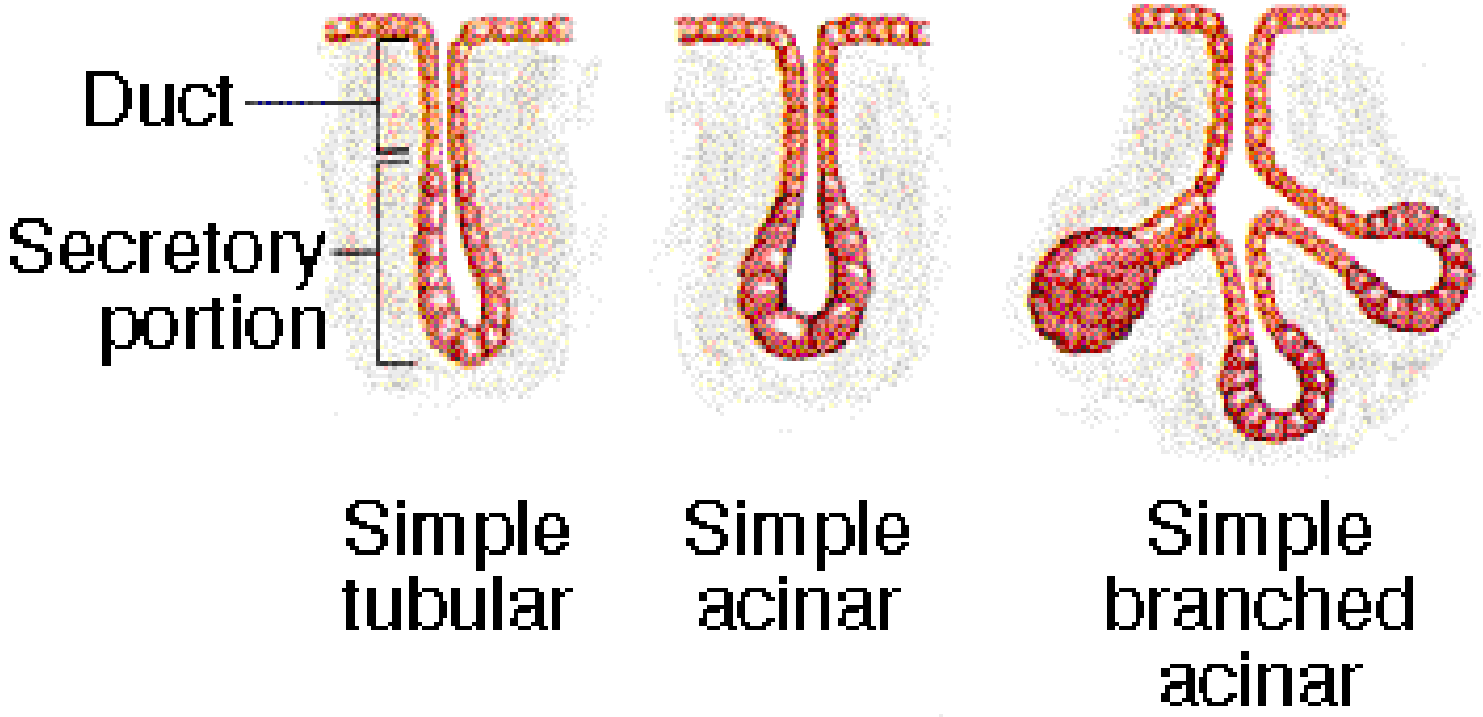


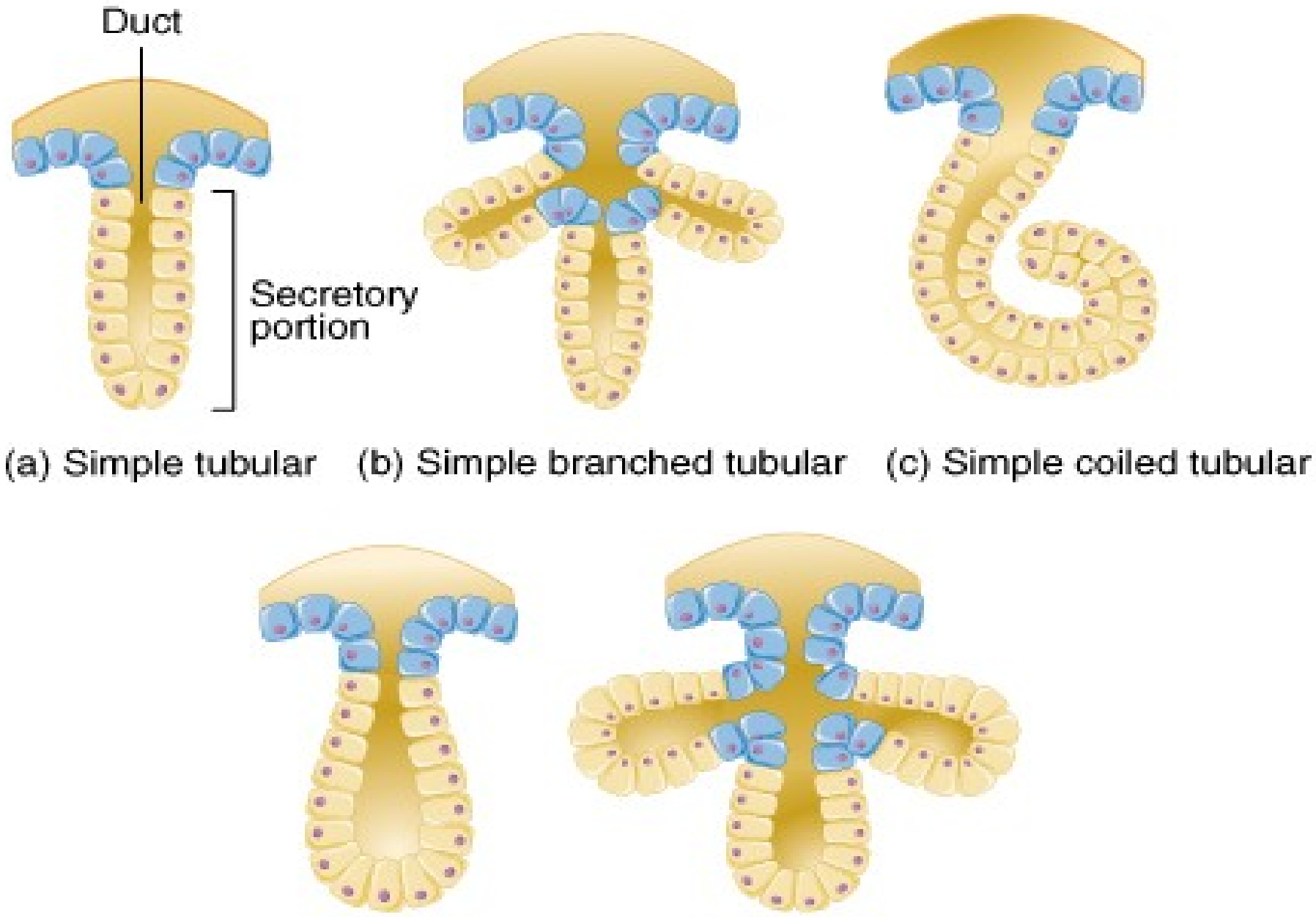
(b) Apocrine secretion

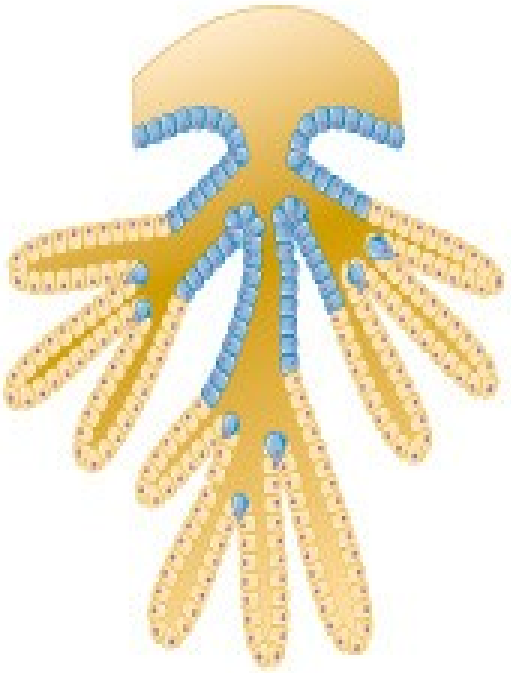


(c) Holocrine secretion

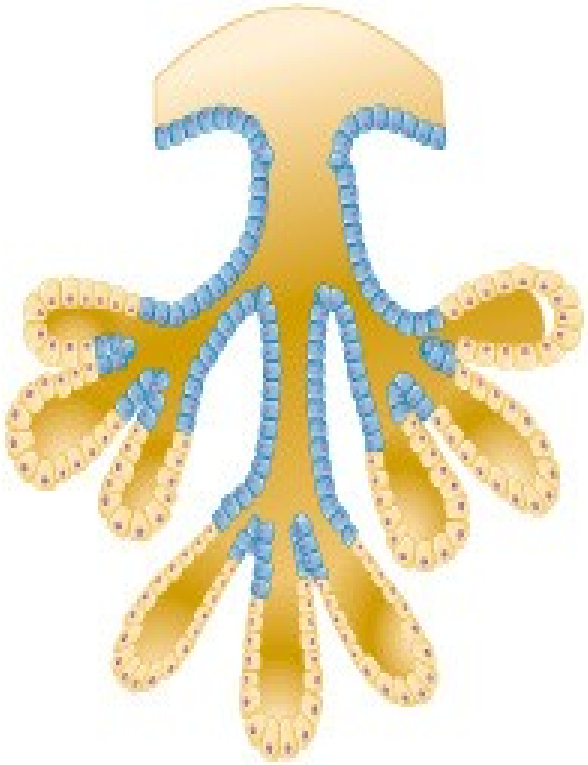
Structure of Exocrine Glands. Figure 1.15



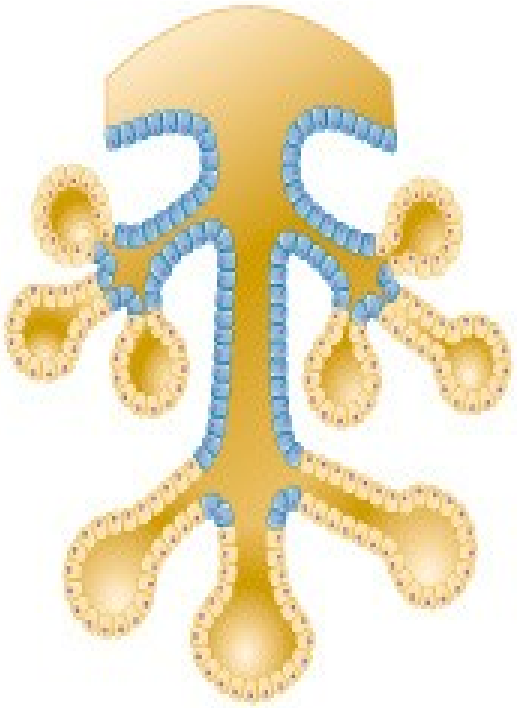

Duct
Secretory portion
(a) Simple tubular
(b) Simple branched tubular
(c) Simple coiled tubular
(d) Simple acinar
(e) Simple branched acinar



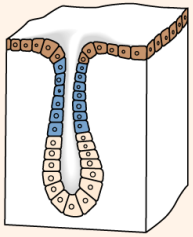
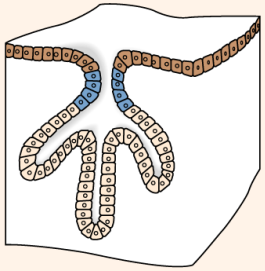
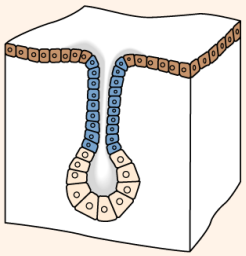
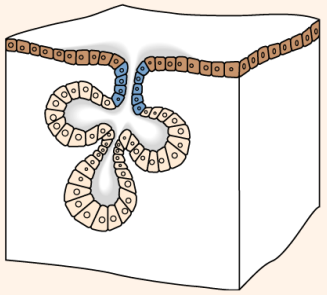
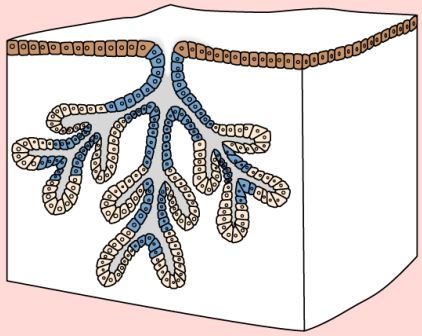
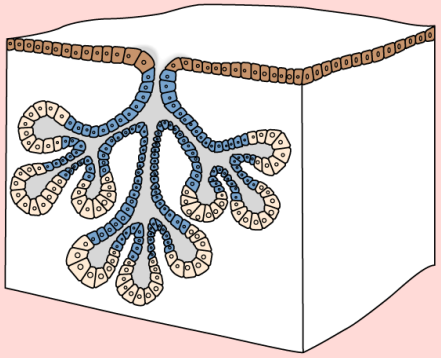
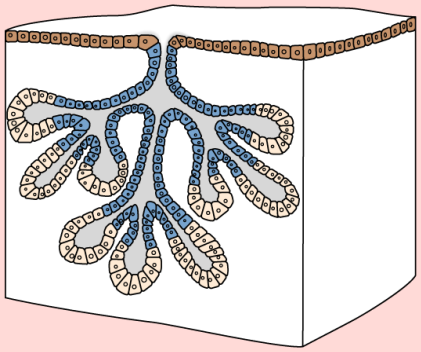
(f) Compound tubular



(g) Compound acinar



(h) Compound tubuloacinar

	Tubularsecretory structure		Alveolarsecretory structure	
Simple duct structure (duct does not branch)	 **(a) Simple tubular** Example: intestinal glands	 **(b) Simple branched tubular** Example: stomach (gastric) glands	 **(c) Simple alveolar** Example: No important example in humans	 **(d) Simple branched alveolar** Example: sebaceous (oil) glands
Compound duct structure (duct branches)	 **(e) Compound tubular** Example: Brunner's glands of small intestines	 **(f) Compound alveolar** Example: mammary glands	 **(g) Compound tubuloalveolar** Example: salivary glands	

KEY: =Surface epithelium =Duct =Secretory epithelium

MEMBRANES

Membranes

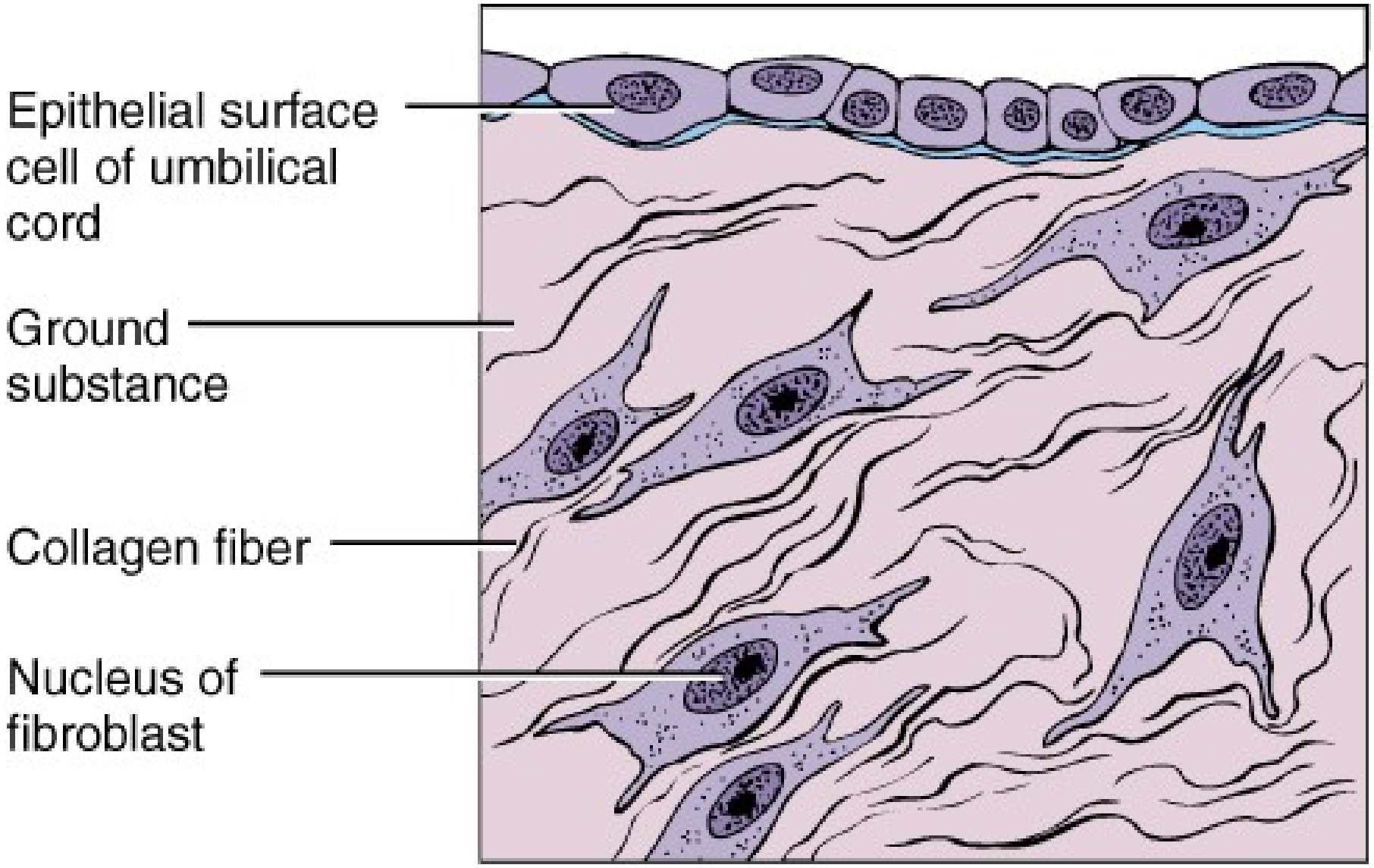
- Membranes are flat sheets of pliable tissue that cover or line a part of the body:
  - **Epithelial membranes** consist of an epithelial layer and an underlying connective tissue layer.
  - **Synovial membranes** line joints and contain only connective tissue.

Epithelial Membranes

- Epithelial membranes include:
  - *mucous membranes*,
  - *serous membranes*, and the
  - *cutaneous membrane* or skin

Epithelial Membranes

- *Mucous membranes* (**mucosae**) line cavities that open to the exterior, such as the gastrointestinal tract.
  - The epithelial layer of a mucous membrane is an important aspect of the body's defense mechanisms, acting as a barrier to pathogens and a trapping surface for particles.
  - The connective tissue layer of a mucous membrane is called the ***lamina propria***.



Mucous connective tissue

Epithelial Membranes

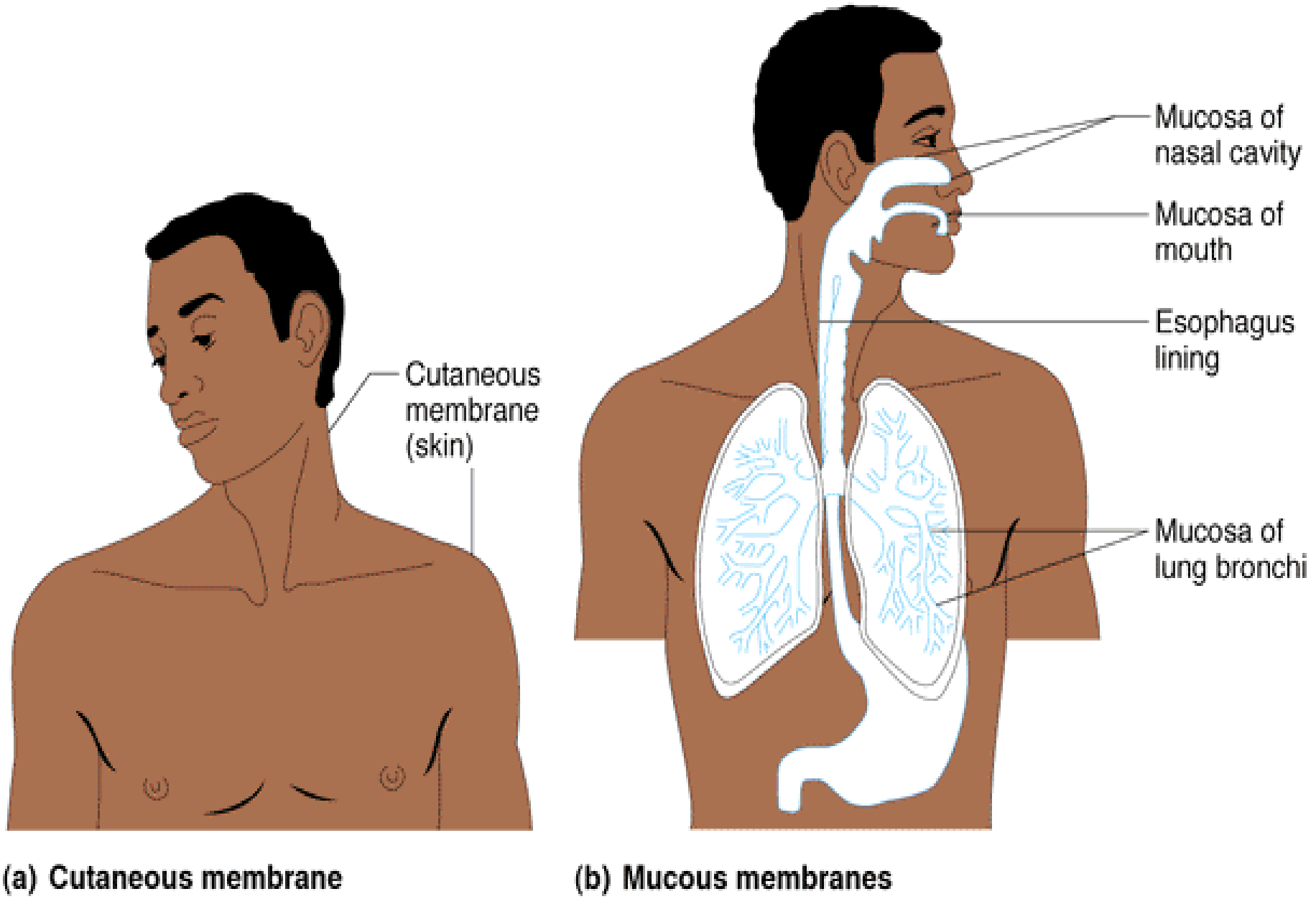
- A *serous membrane*, or serosa, lines a body cavity that does not open directly to the exterior & covers the organs that lie within the cavity.
- Examples include the pleura, pericardium, and peritoneum.
- These membranes consist of **parietal** and **visceral** portions.

Epithelial Membranes

- The epithelial layer secrets a lubricating serous fluid that reduces **friction** between organs & the walls of the cavities in which they are located.

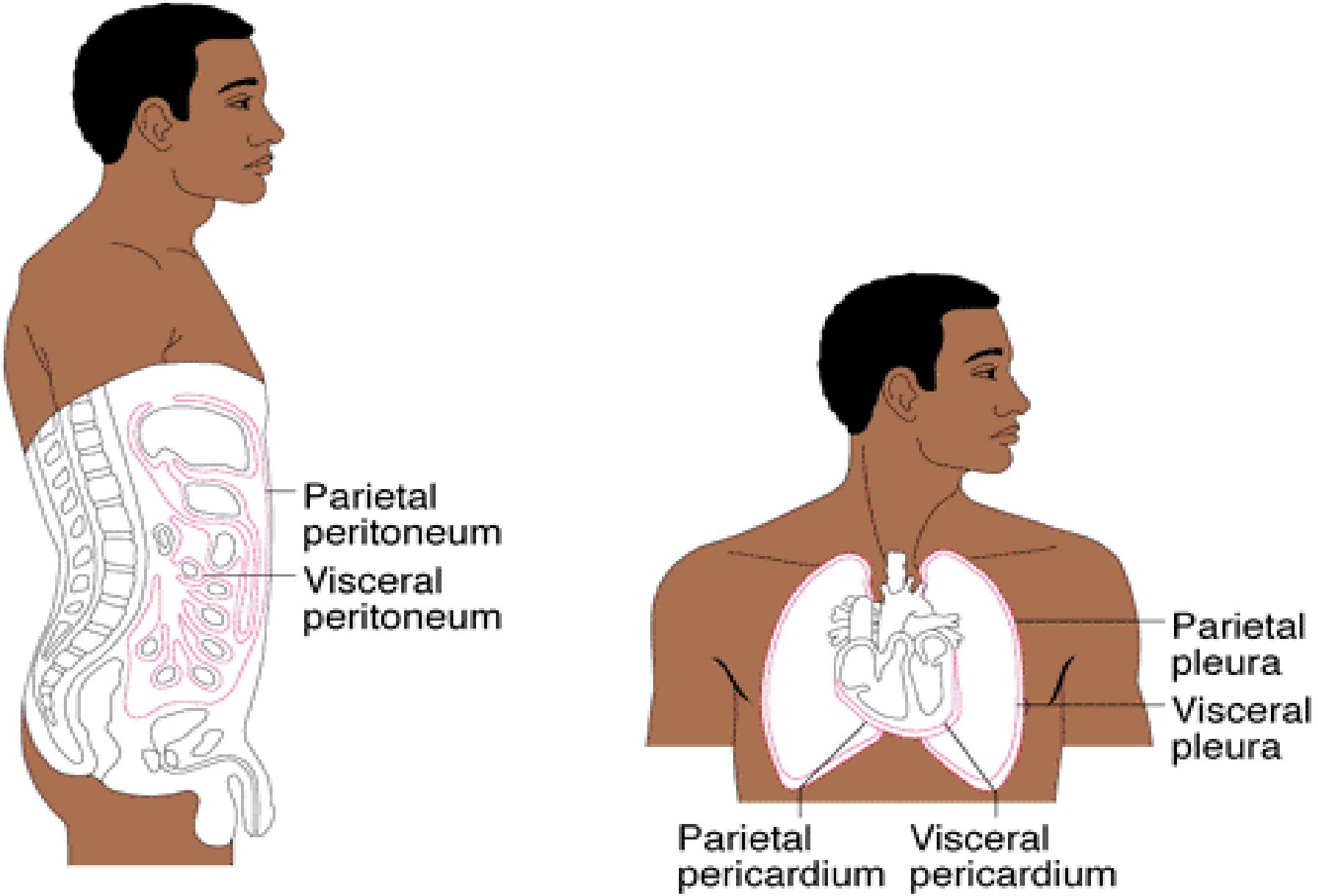
Synovial Membranes

- *Synovial membranes* line joint cavities, bursae, and tendon sheaths and do not contain epithelium.
- They also secrete a lubricating synovial fluid.

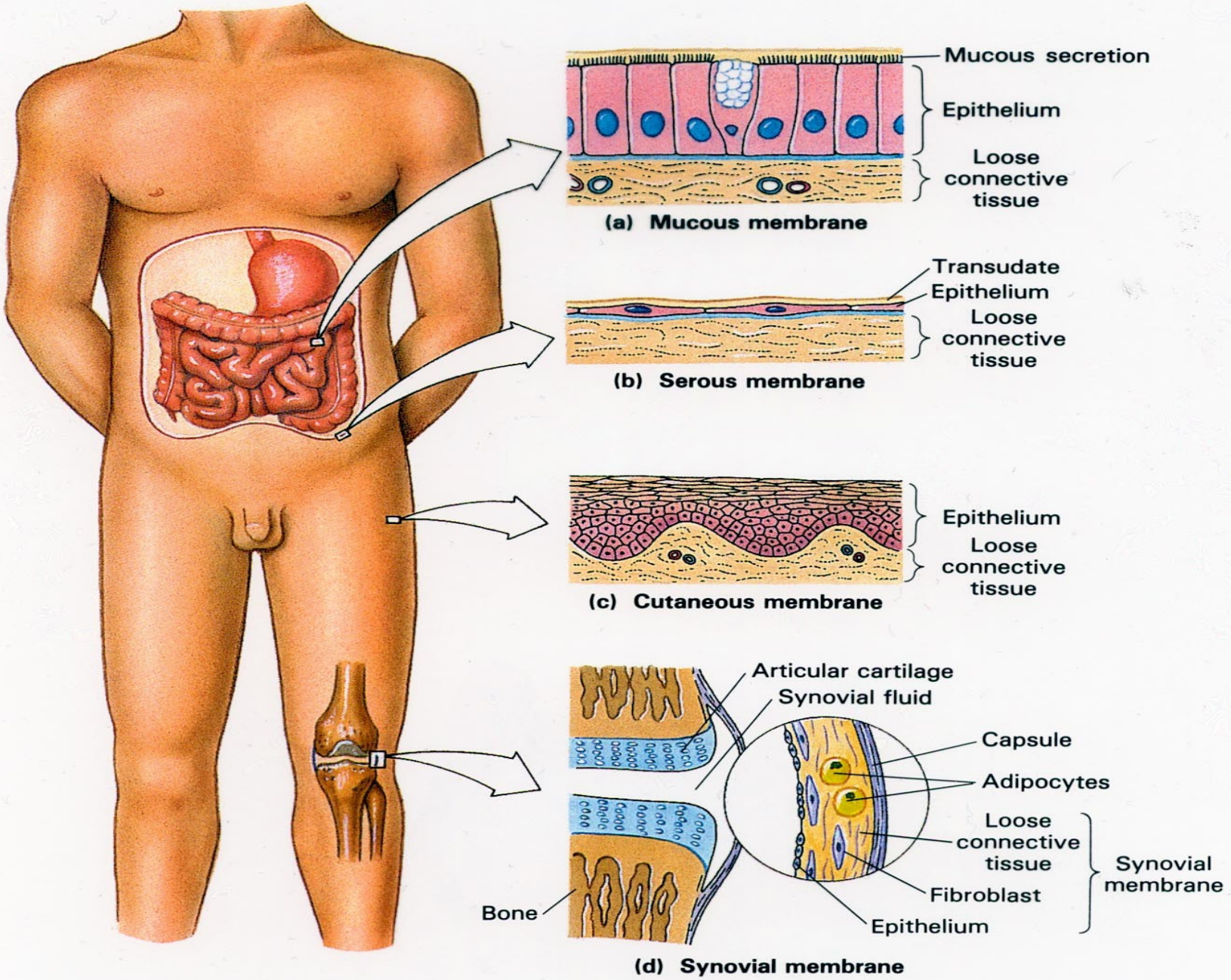


(a) Cutaneous membrane

(b) Mucous membranes



(c) Serous membranes


Mucous secretion
Epithelium
Loose connective tissue
(a) Mucous membrane
Transudate
Epithelium
Loose connective tissue
(b) Serous membrane
Epithelium
Loose connective tissue
(c) Cutaneous membrane
Articular cartilage
Synovial fluid
Capsule
Adipocytes
Loose connective tissue
Fibroblast
Epithelium
Synovial membrane
Bone
(d) Synovial membrane

CONNECTIVE TISSUE (CT)

CONNECTIVE TISSUE (CT)

- Most abundant and widely distributed tissue in the body
- **Functions**:
  - Binds, supports, strengthens
  - Protects, insulates
  - Compartmentalizes
  - Transports
  - Energy reserve

CLASSIFICATION OF CT

- Loose CT
  - Areolar, adipose, reticular
- Dense CT
  - regular, irregular, elastic
- Cartilage
  - Hyaline, fibrocartilage, elasticcartilage
- Bone
- Blood

Features of CT

- Consists of cells and matrix
- **Cells**: -**blasts** and -**cytes**
  - Macrophages
  - Plasma and Mast cells
- **Matrix**
  - Ground substance
  - Fibers
  - Fluid to calcified states

Connective Tissue

- *Connective tissue* is the most abundant and widely distributed tissue in the body.
- General features of connective tissue
  - Connective tissue consists of three basic elements: cells, ground substance, and fibers (the latter two of which combine to form the *matrix*).

Connective Tissue

- **Matrix** is abundant with relatively few cells and tends to prevent tissue cells from touching one another.
- The matrix of a connective tissue, which may be fluid, semifluid, gelatinous, fibrous, or calcified, is usually secreted by the connective tissue cells and adjacent cells and determines the tissue's qualities.

Connective Tissue

1. Unlike epithelia, connective tissues do not occur on free surfaces.
2. Unlike epithelium, connective tissue is **highly vascular** (except for **cartilage** and **tendons**).
3. Except for **cartilage**, connective tissue, like epithelium, has a **nerve supply**.

CT Cells

- Cells in connective tissue are derived from ***mesenchyme.***
- Immature cells have names that end in -***blast*** (e.g., **fibroblast, chondroblast**) while mature cells have names that end in -***cyte*** (e.g., **osteocyte**).
- Most mature cells have reduced capacity for cell division and matrix formation and are mostly involved in maintaining the matrix.

CT Cells

- Types of cells found in various connective tissues include:
  - *fibroblasts* (which secrete fibers and matrix),
  - *macrophages* (or histiocytes, which develop from monocytes and are phagocytic),

CT Cells

- *plasma cells* (which develop into antibody-producing B lymphocytes, or B cells),
- *mast cells* (which are abundant alongside blood vessels and produce histamine),

CT Cells

- Types of cells found in various connective tissues include:
  - *adipocytes* (or fat cells, which store energy in the form of fat), and
  - *white blood cells* (or leukocytes). (Fig. 4.5)

Connective Tissue Matrix

- The ground substance and fibers, deposited in the space between the cells, comprise the matrix of connective tissue.
- Substances found in the ground substance include hyaluronic acid, chondroitin sulfate, dermatan sulfate, and keratan sulfate.

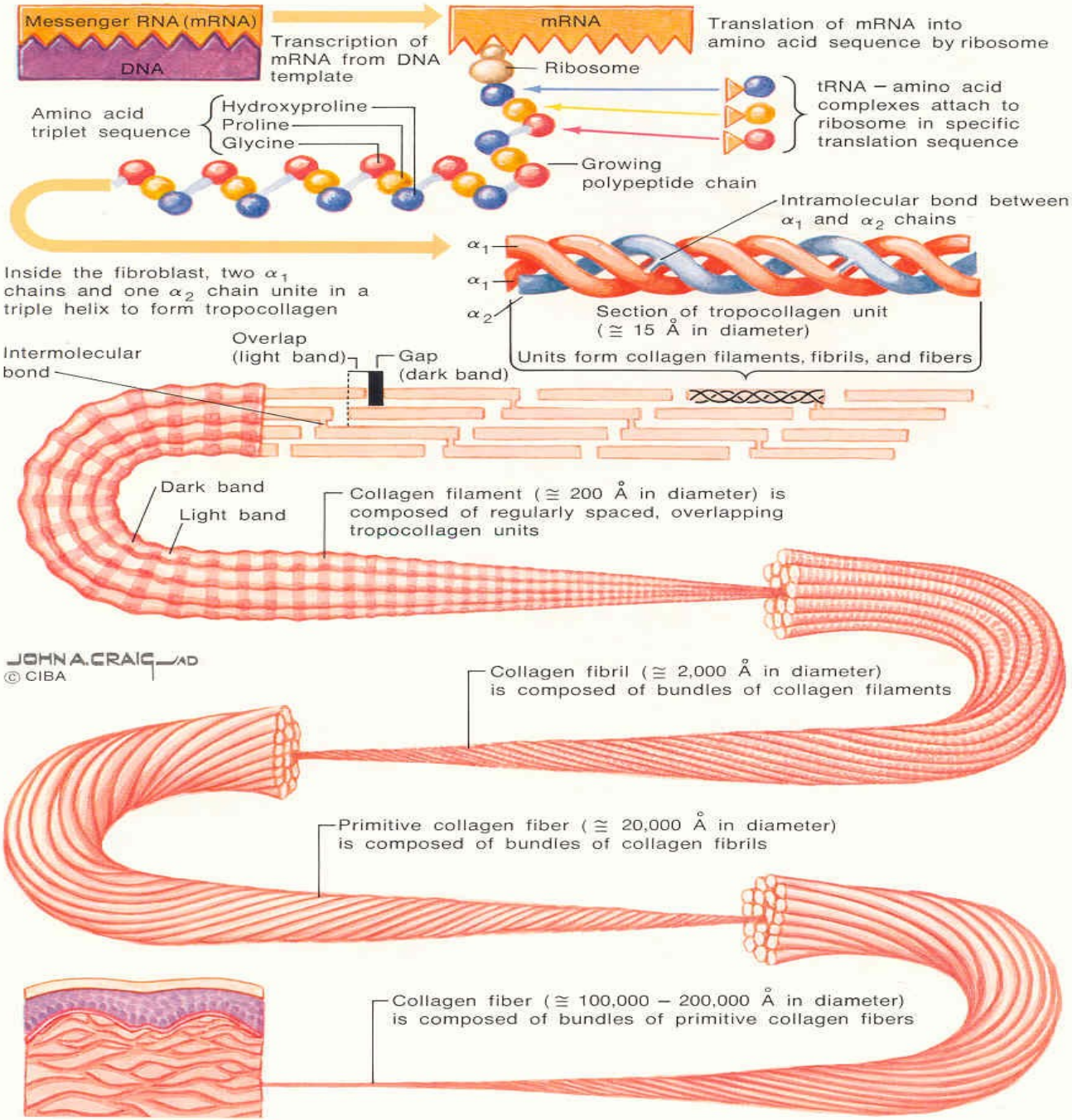
Connective Tissue Matrix

- The function of ground substance is that it supports, binds, and provides a medium for the exchange of materials between the blood and cells, and is active in influencing cell functions.

Connective Tissue Fibers

- Fibers in the matrix provide strength and support for tissues.
- Three types of fibers are embedded in the matrix between cells of connective tissues
  - **Collagen**
  - **Elastic**
  - **Reticular**

Collagen Synthesis



Connective Tissue Fibers

- ***Collagen fibers***, composed of the protein collagen, are very tough and resistant to stretching, yet allow some flexibility in tissue;
- They are found in
  - **bone,**
  - **cartilage,**
  - **tendons**, and
  - **ligaments**.

Connective Tissue Fibers

- ***Elastic fibers***, composed of the protein elastin, provide strength and stretching capacity and are found in skin, blood vessels, and lungs.

Connective Tissue Fibers

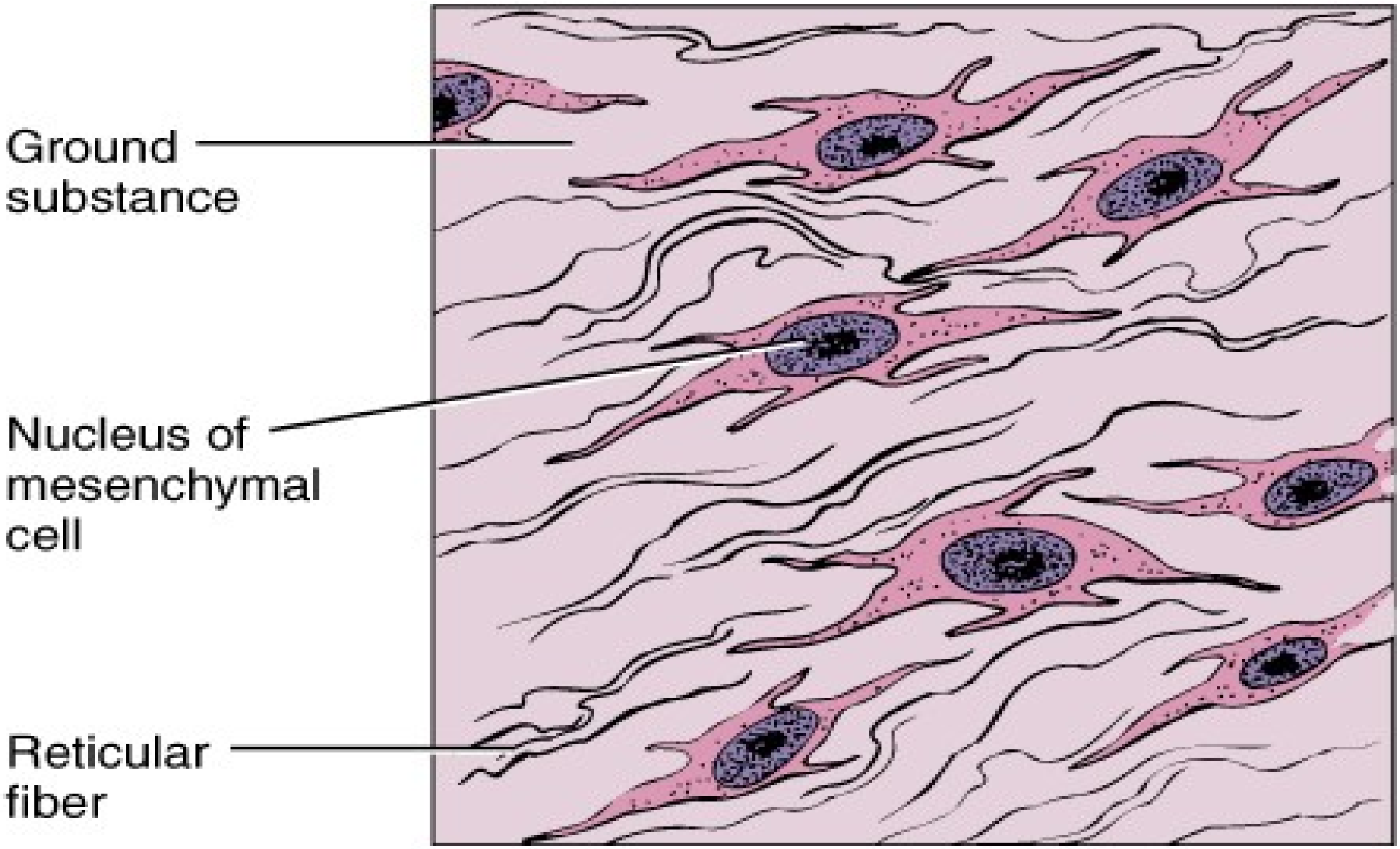
- ***Reticular fibers***, consisting of collagen and glycoprotein, provide support in the walls of blood vessels and form a strong, supporting network around fat cells, nerve fibers, and skeletal and smooth muscle fibers.

Classification of Connective Tissue

- Embryonic Connective Tissue
  - Connective tissue that is present primarily in the embryo or fetus is called *embryonic connective tissue*.
  - ***Mesenchyme***, found almost exclusively in the embryo, is the tissue form from which all other connective tissue eventually arises.
  - *Mucous connective tissue* (Wharton's jelly) is found in the umbilical cord of the fetus.

Types of Mature Connective Tissue

- Mature connective tissue exists in the newborn, has cells differentiated from *mesenchyme*, & does not change after birth.
  - It is subdivided into several kinds:
    - connective tissue proper,
    - cartilage,
    - bone tissue, and
    - blood.


Ground substance
Nucleus of mesenchymal cell
Reticular fiber

Mesenchyme

Types of Mature Connective Tissue

- Subtypes include:
  - **Loose connective tissue**, and
  - **Dense connective tissue**,

Loose CT

- *Loose connective tissue* consists of all three types of fibers, several types of cells, and a semifluid ground substance.
  - *Areolar connective tissue* is a prime example of loose connective tissue.
  - It shows all of the typical loose connective tissue features.

Loose CT

- The **ground substance** aids the passage of nutrients from the blood vessels of the connective tissue into adjacent cells and tissues.
- It is found in the subcutaneous layer of the skin.

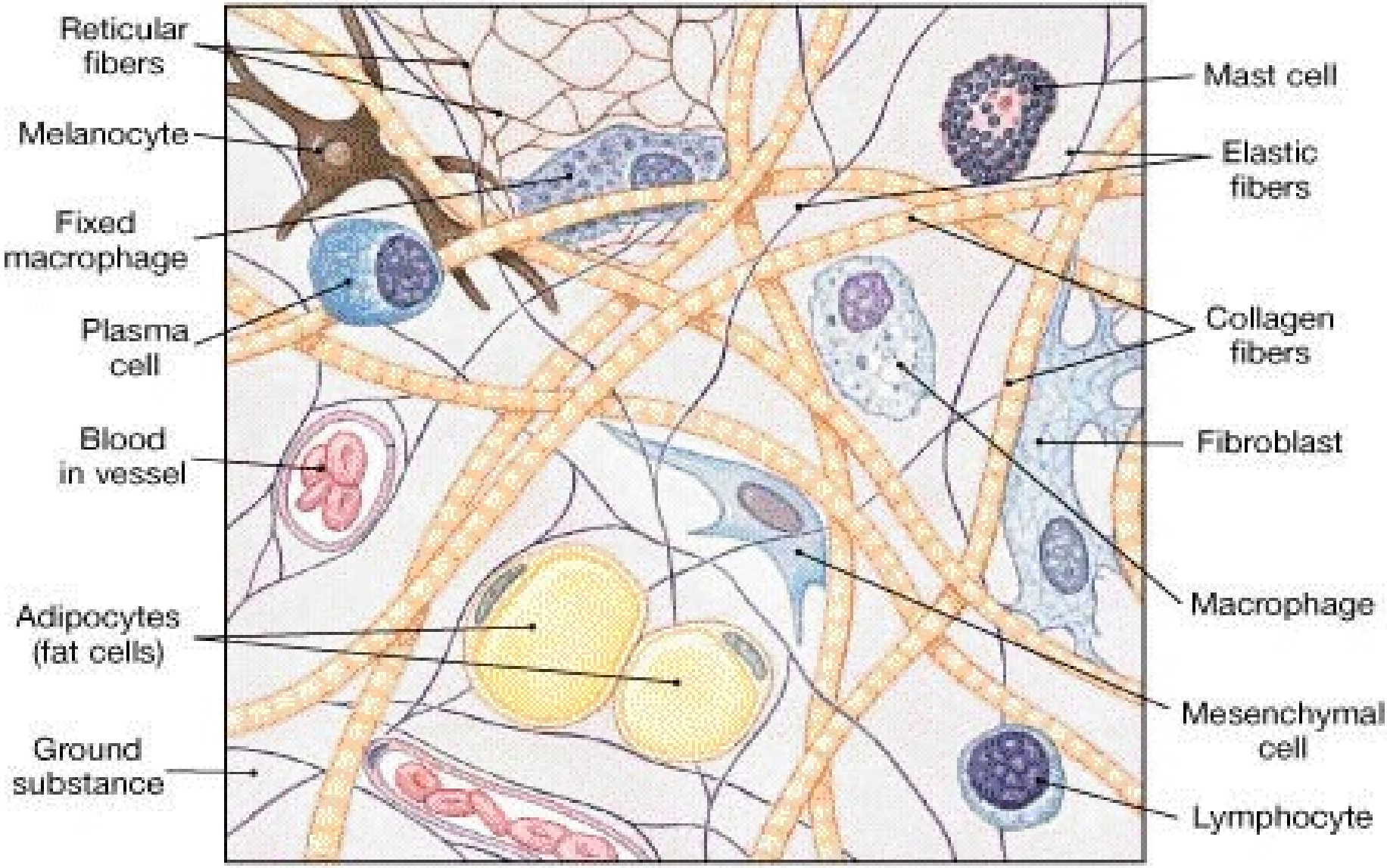
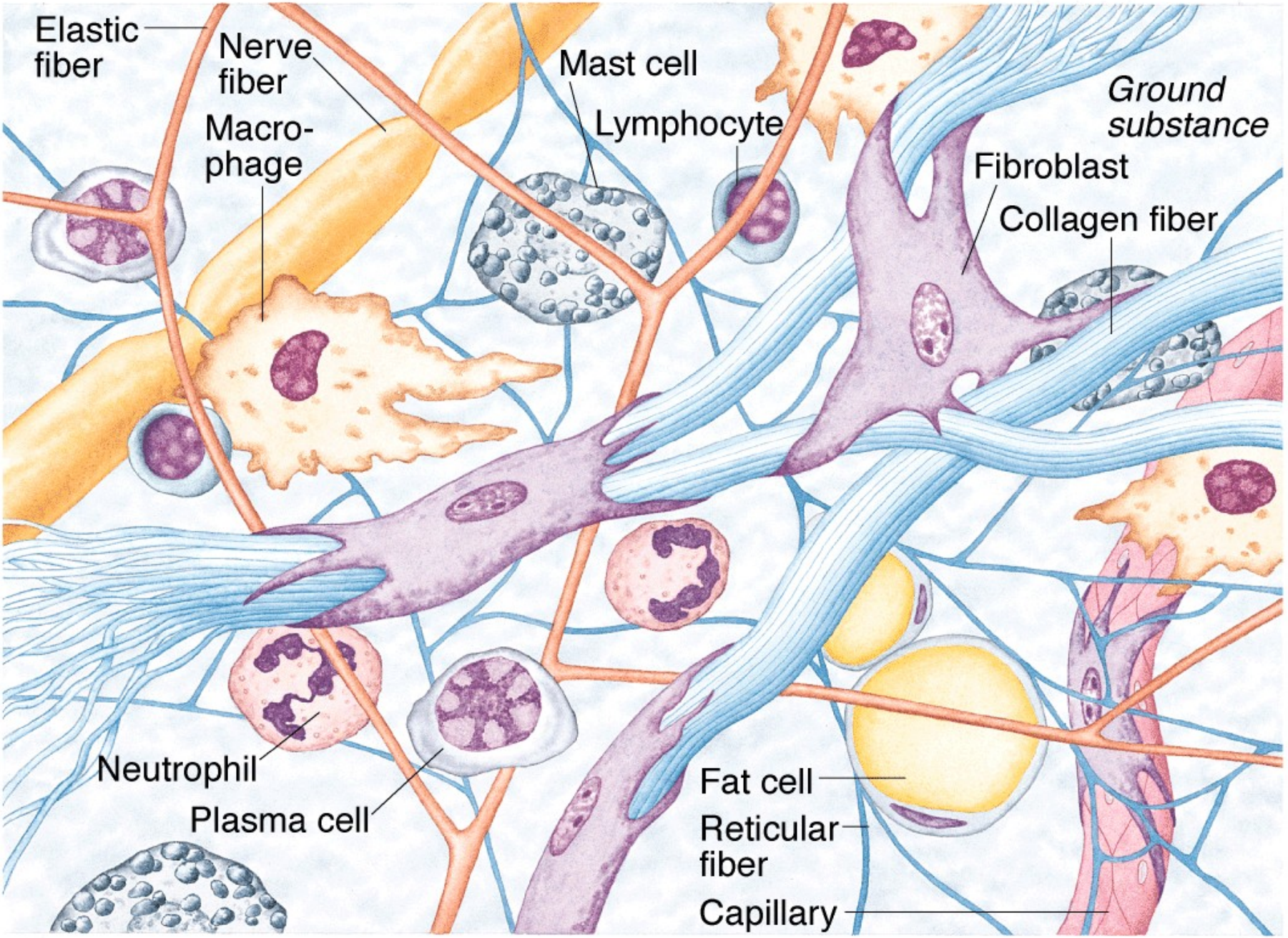
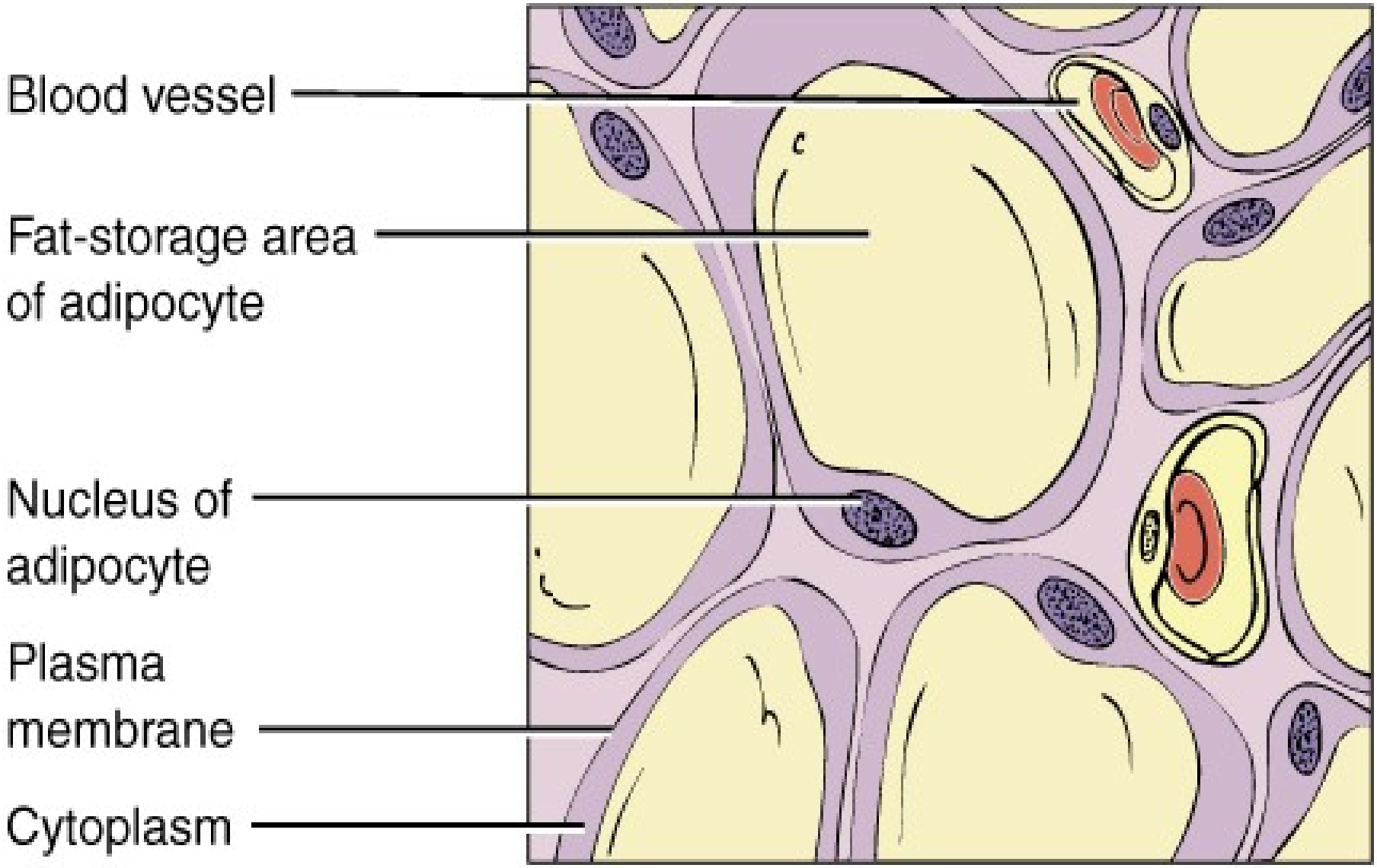


FIGURE 4-8 The Cells and Fibers of Connective Tissue Proper. (a) A summary of the cell types and fibers of connective tissue proper. (LM × 384)

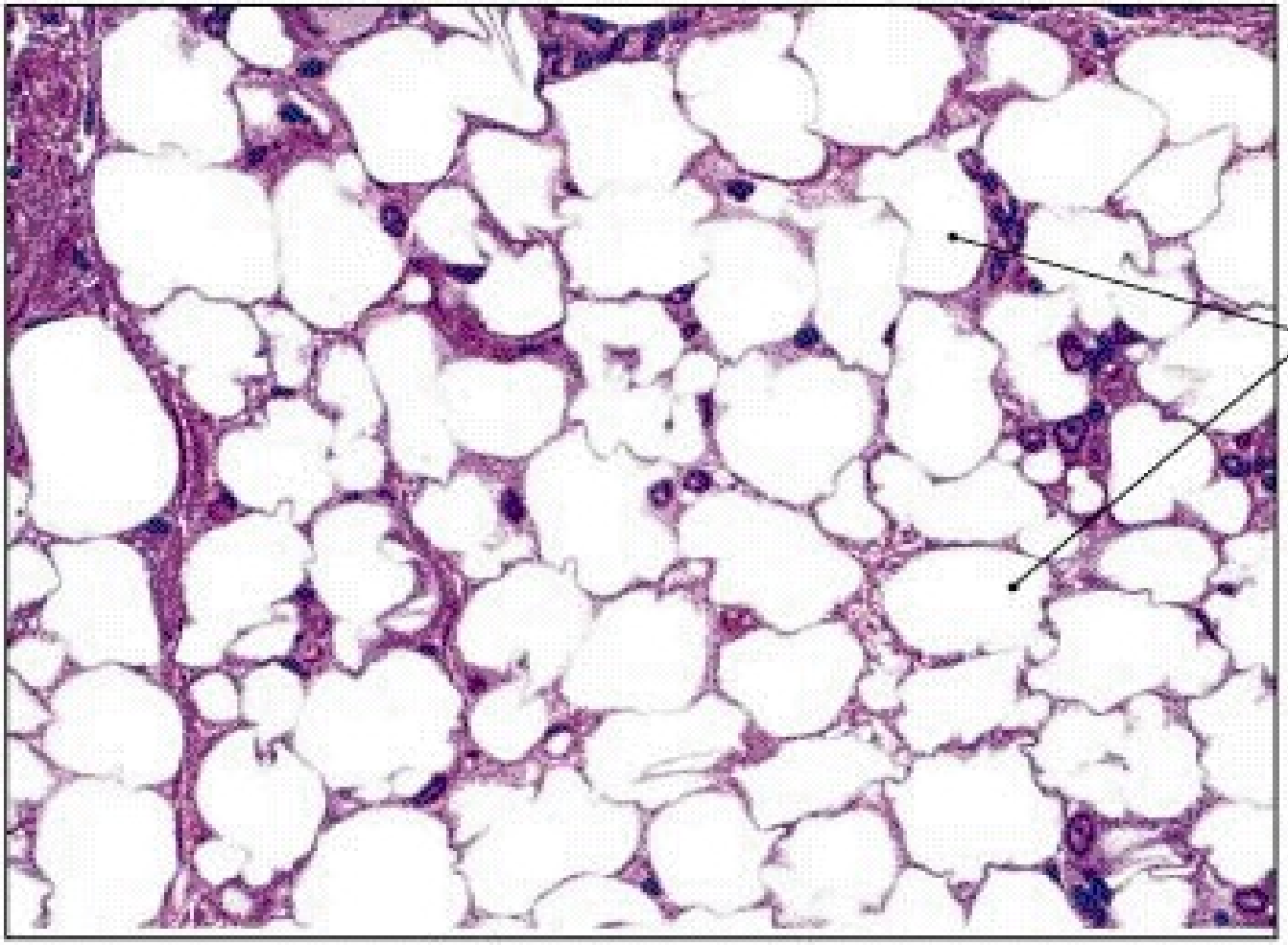


Loose CT

- ***Adipose tissue*** consists of **adipocytes** which are specialized for storage of **triglycerides**.
  - It is found wherever areolar connective tissue is located.
  - It reduces heat loss through the skin, serves as an energy reserve, supports, protects, and generates considerable heat to help maintain proper body temperature in newborns (brown fat).



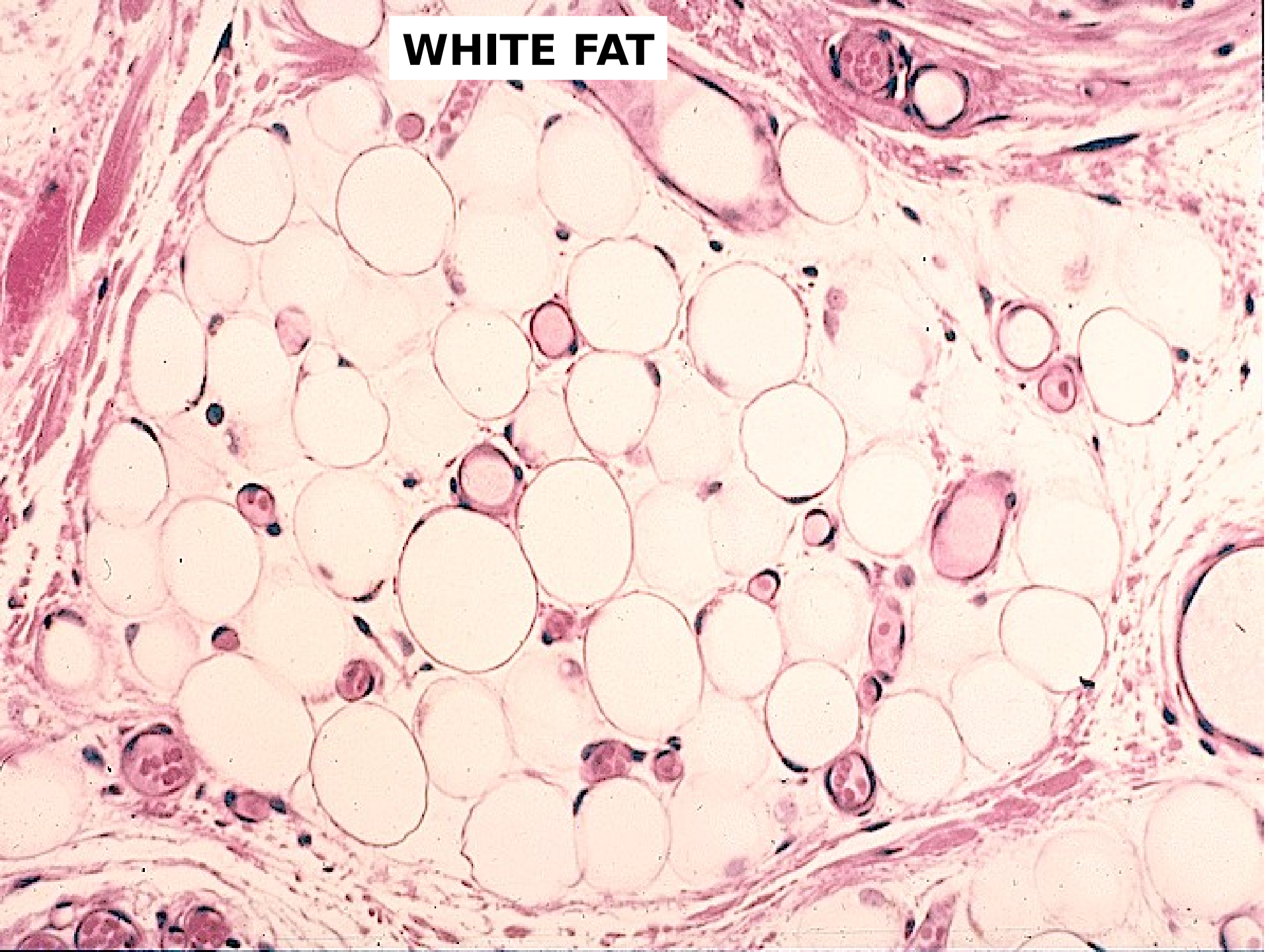
Adipose tissue



Adipose tissue × 118

(a)

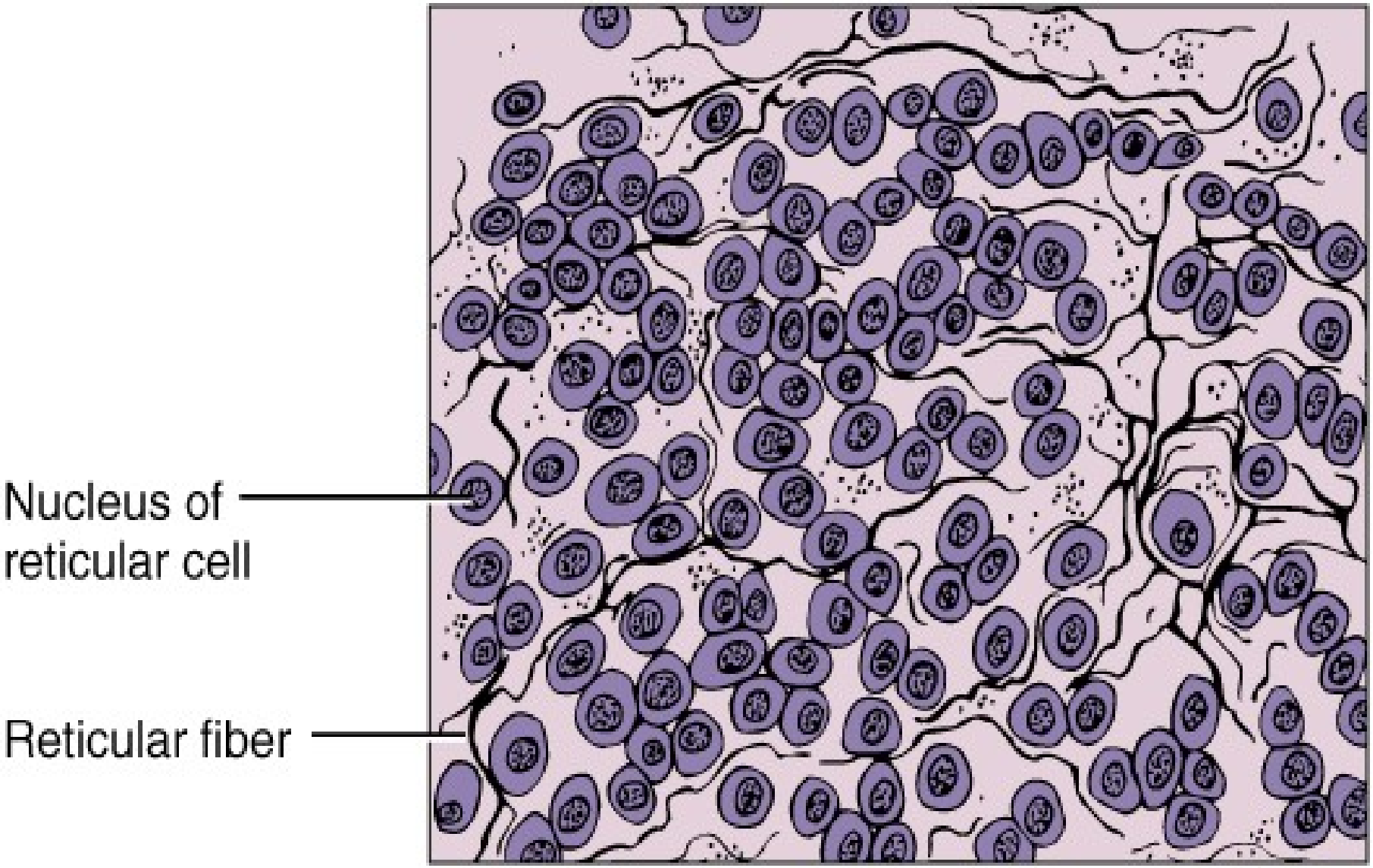
FIGURE 4-9 Adipose Tissue. (a) Adipose tissue is a loose connective tissue that is dominated by adipocytes. In standard histological preparations, the tissue looks empty because the lipids in the fat cells dissolve in the alcohol used in tissue processing.


WHITE FAT


BROWN FAT

Loose CT

- ***Reticular connective tissue*** consists of fine interlacing **reticular fibers** and **reticular cells**.
  - It forms the stroma of certain organs.
  - It helps to bind together the cells of smooth muscle.



Reticular connective tissue

Loose Connective Tissue

(1) Areolar

composition : fibroblasts, macrophages, mast cells, adipocytes, and plasma cells; collagen, elastic, and reticular fibers ; semifluid ground substance.

location : skin (subcutaneous layer and papillary region); mucous membranes; around blood vessels, nerves, and body organs.

function : strength; elasticity; support.

(2) Adipose

composition : adipocytes; reticular fibers.

location : skin (subcutaneous layer); around heart and kidneys; yellow bone marrow; padding around joints; behind eyeball in eye socket.

function : energy reserve (stores triglycerides); insulation; support; protection.

(3) Reticular

composition : reticular cells; reticular fibers.

location : liver; spleen; lymph nodes; basal lamina (underlying epithelial cells).

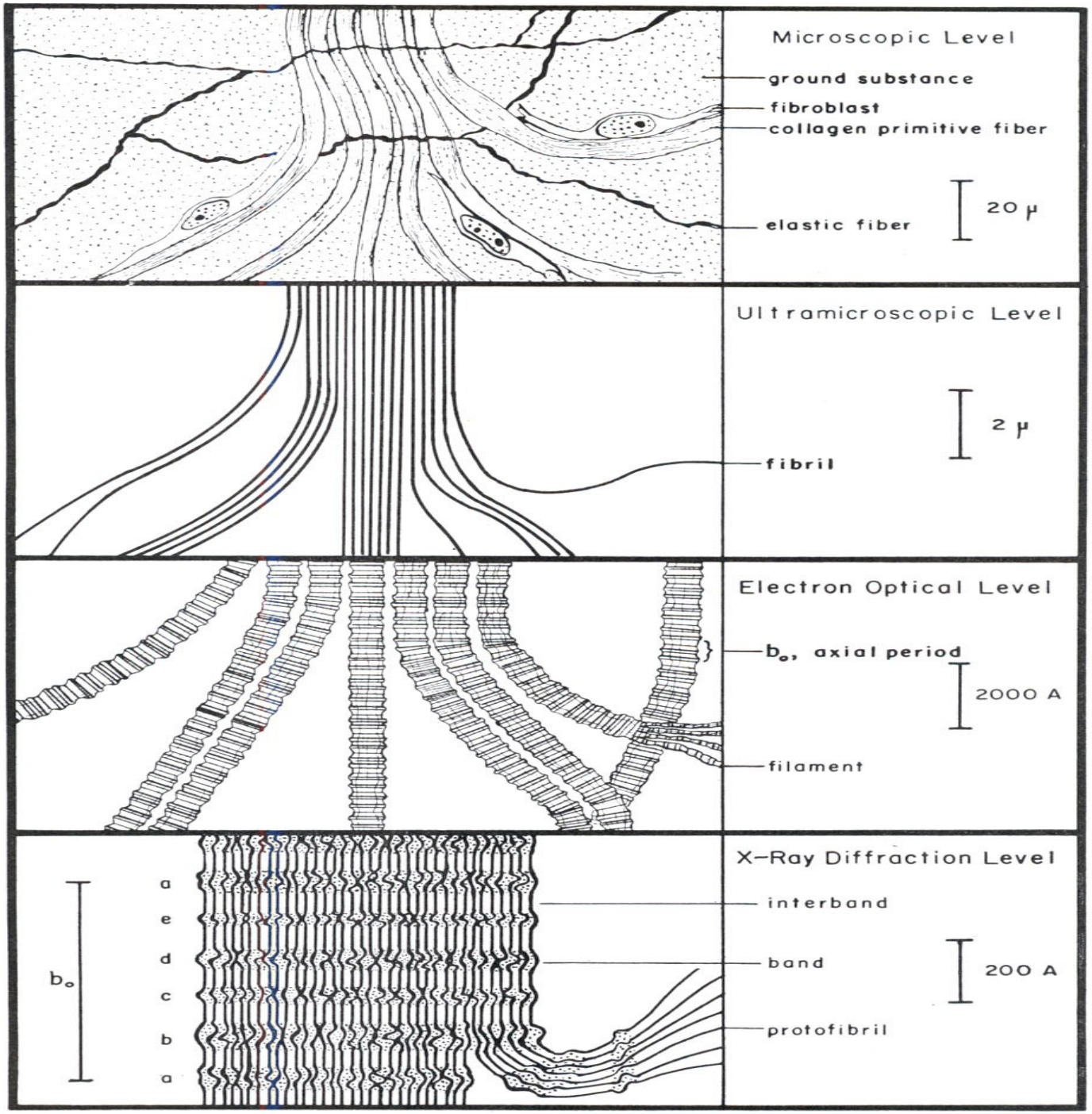
function : binds together smooth muscle cells; forms framework (stroma) of organs.

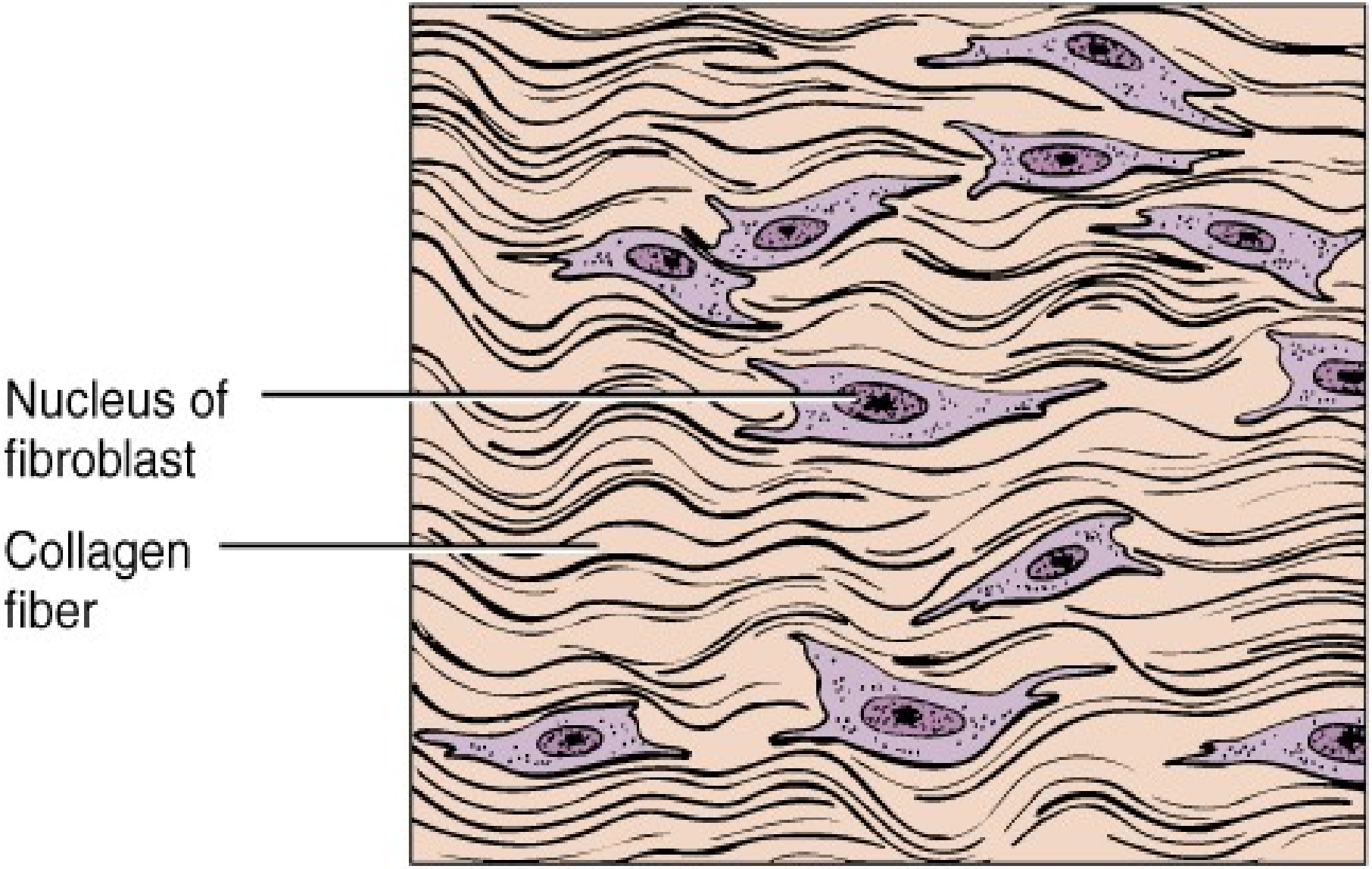
Dense CT

- Contains more numerous, thicker, and dense fibers but considerably fewer cells than loose connective tissue.
- Three types are described as:
  - Dense **Regular** CT
  - Dense **Irregular** CT
  - Dense **Elastic** CT

Dense Regular CT

- *Dense regular connective tissue* consists of bundles of collagen fibers in a regular and orderly, parallel arrangement that confers great strength.


Microscopic Level
ground substance
fibroblast
collagen primitive fiber
elastic fiber
20 μ
Ultramicroscopic Level
2 μ
fibril
Electron Optical Level
b_o, axial period
2000 A
filament
X-Ray Diffraction Level
interband
band
protofibril
200 A
b_o
a
e
d
c
b
a



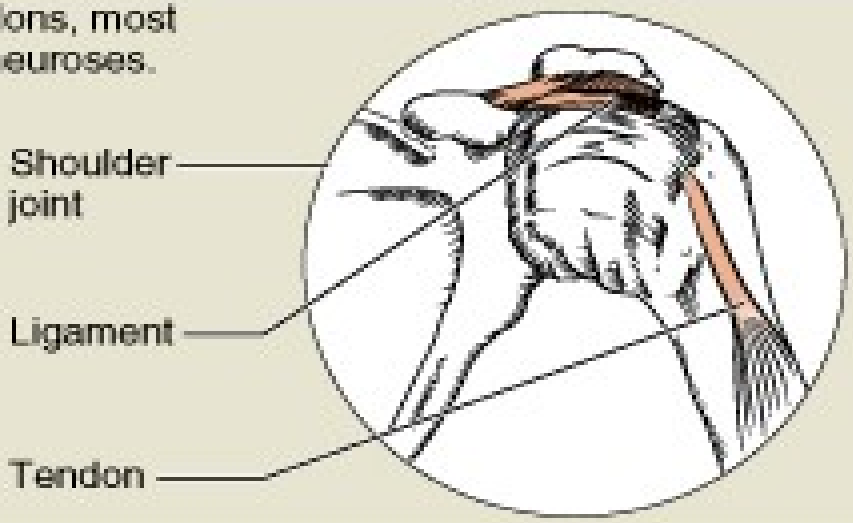
Dense regular connective tissue

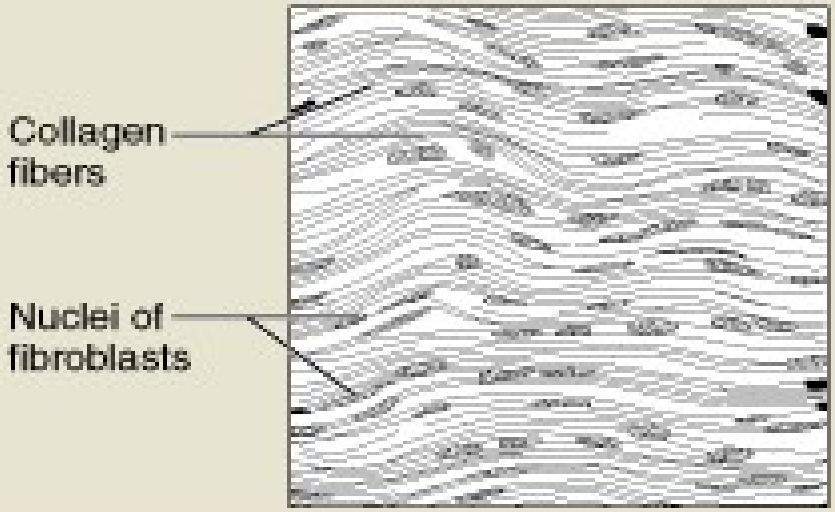
(e) Dense regular connective tissue

Description: Primarily parallel collagen fibers; a few elastin fibers; major cell type is the fibroblast.

Function: Attaches muscles to bones or to muscles; attaches bones to bones; withstands great tensile stress when pulling force is applied in one direction.

Location: Tendons, most ligaments, aponeuroses.





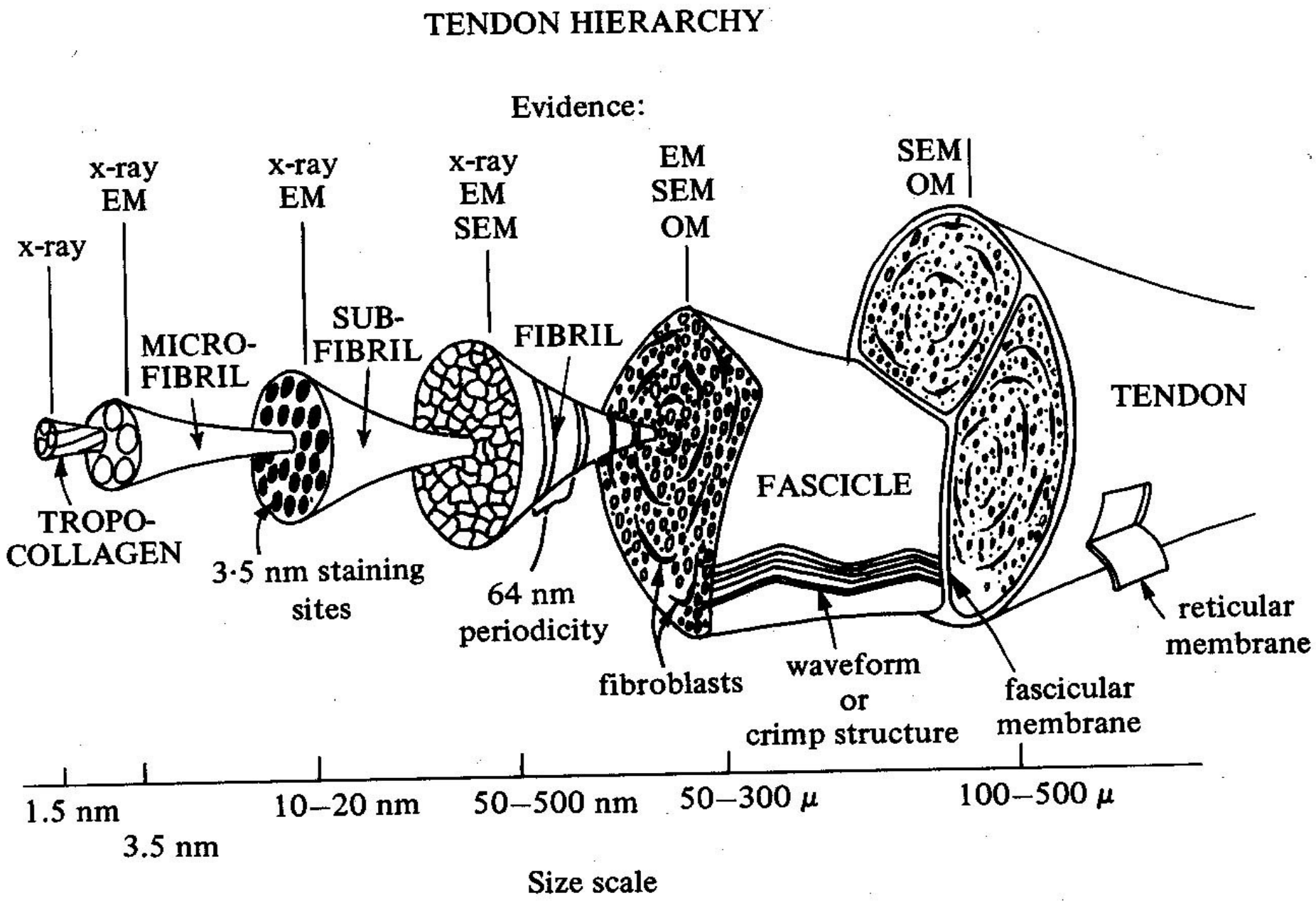
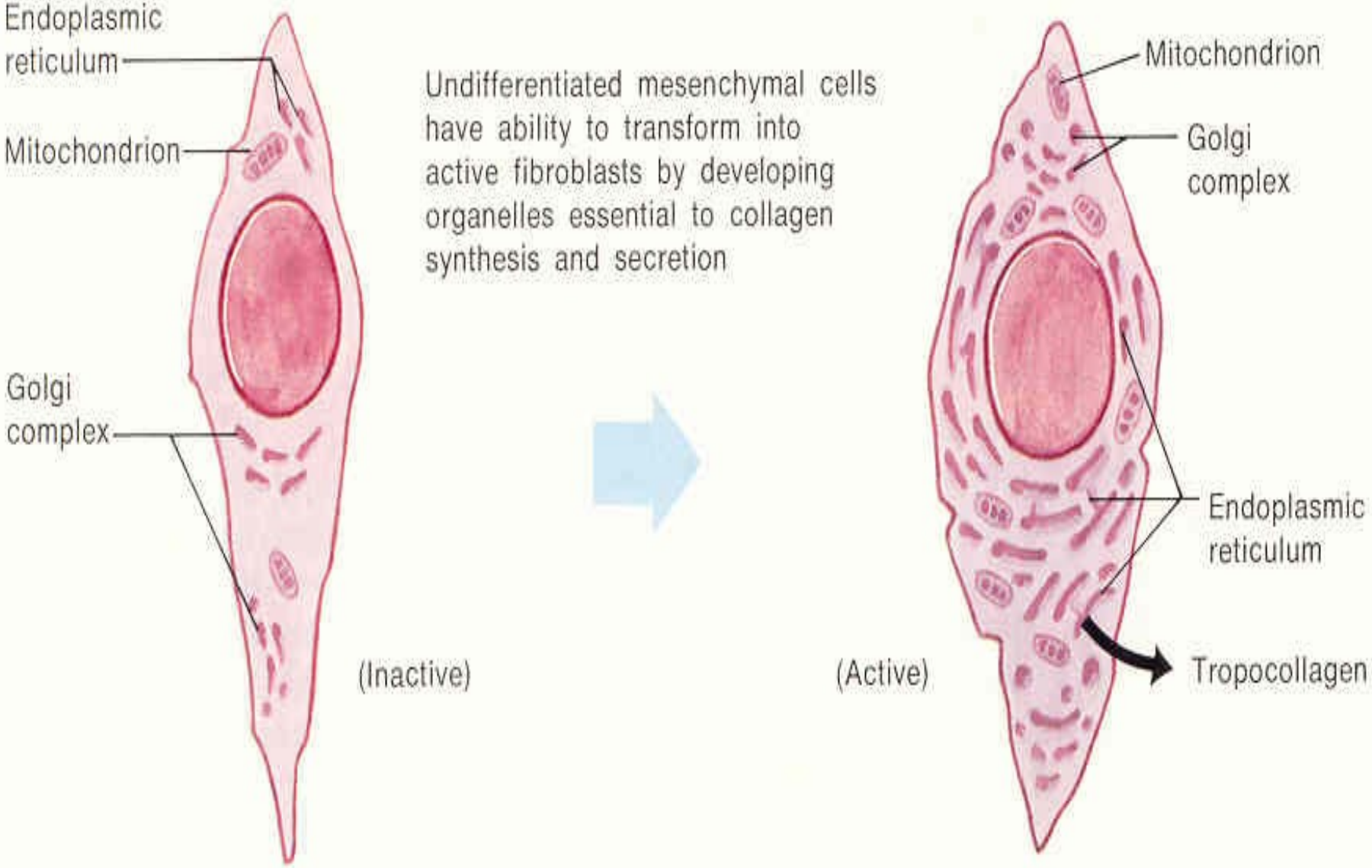


Fig. 1. Hierarchical organization of tendon.

Dense Irregular CT

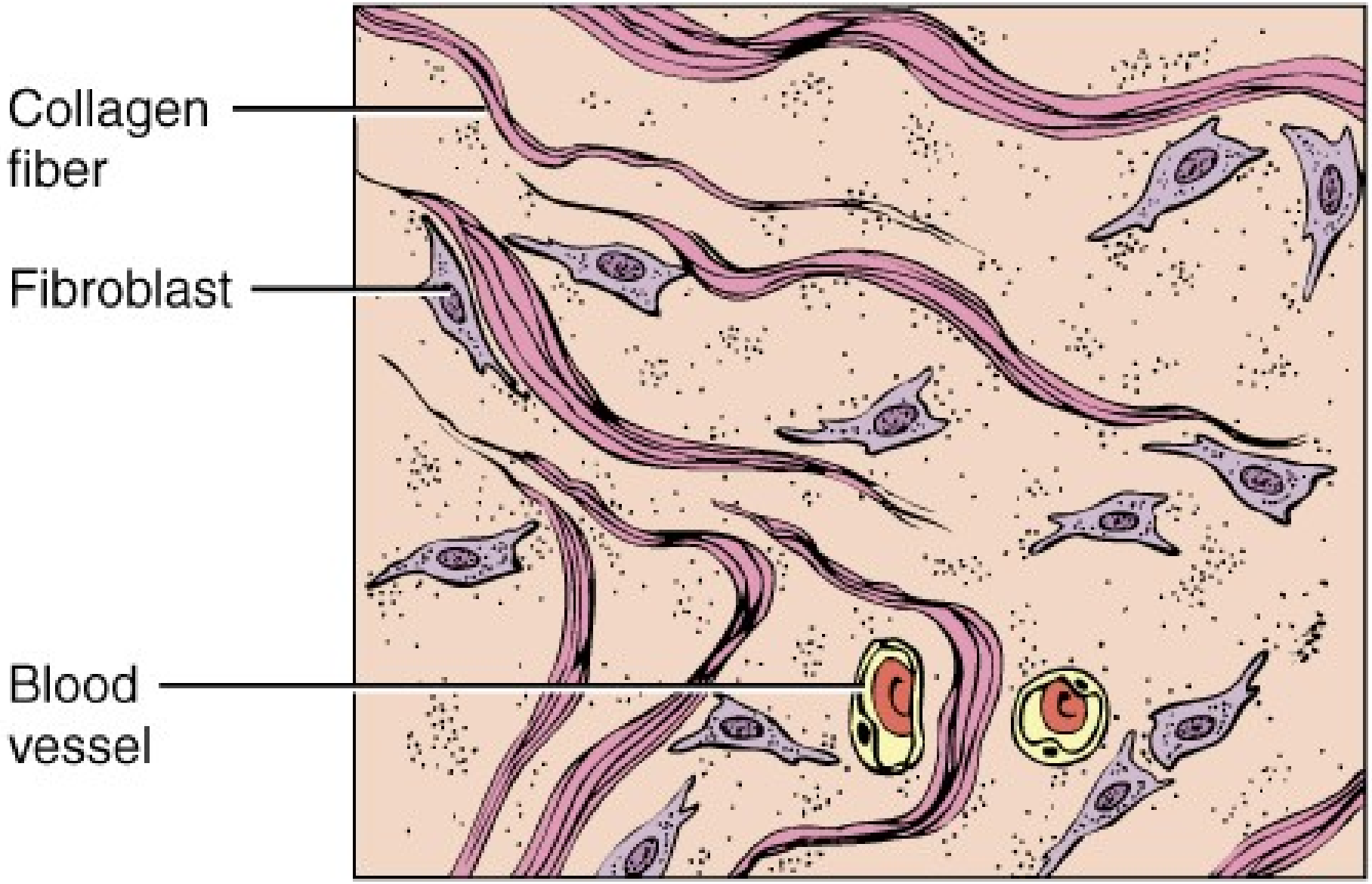
- *Dense irregular connective tissue* contains collagen fibers that are **irregularly** arranged and is found in parts of the body **where tensions** are exerted in various directions.
  - It usually occurs in sheets, such as the **dermis** of the skin.
  - It is also found in heart valves, the perichondrium, the tissue surrounding cartilage, and the **periosteum**.

Fibroblast Transformation



Undifferentiated mesenchymal cell

Mature, collagen-producing fibroblast



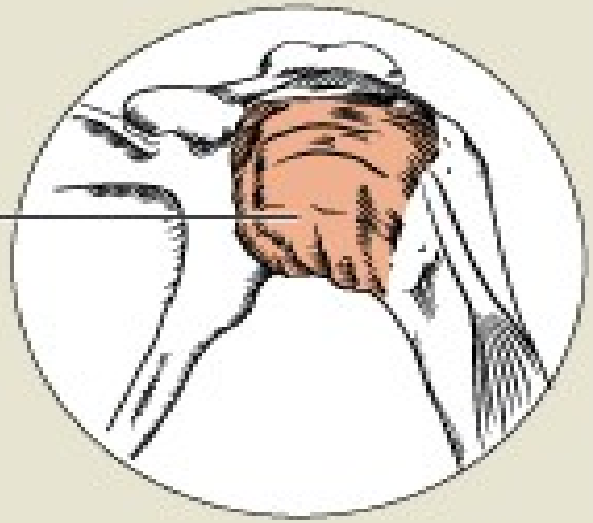
Dense irregular connective tissue

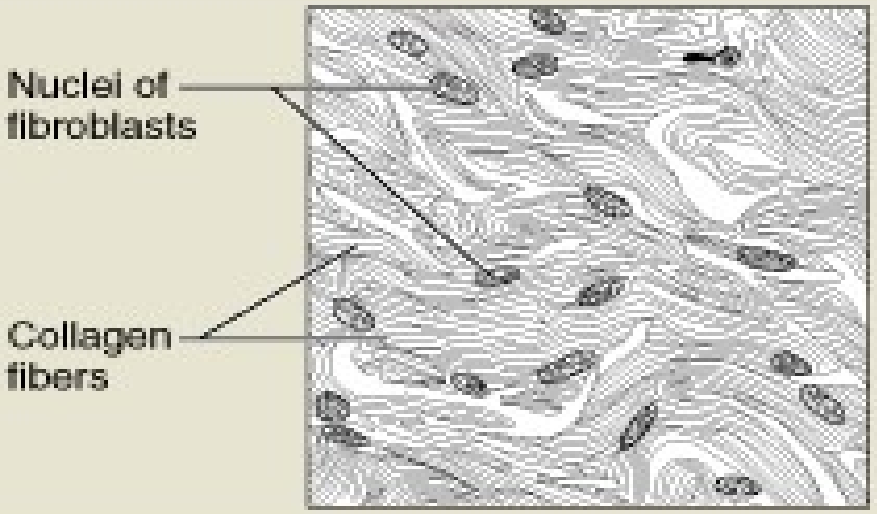
(f) Dense irregular connective tissue

Description: Primarily irregularly arranged collagen fibers; some elastic fibers; major cell type is the fibroblast.

Function: Able to withstand tension exerted in many directions; provides structural strength.

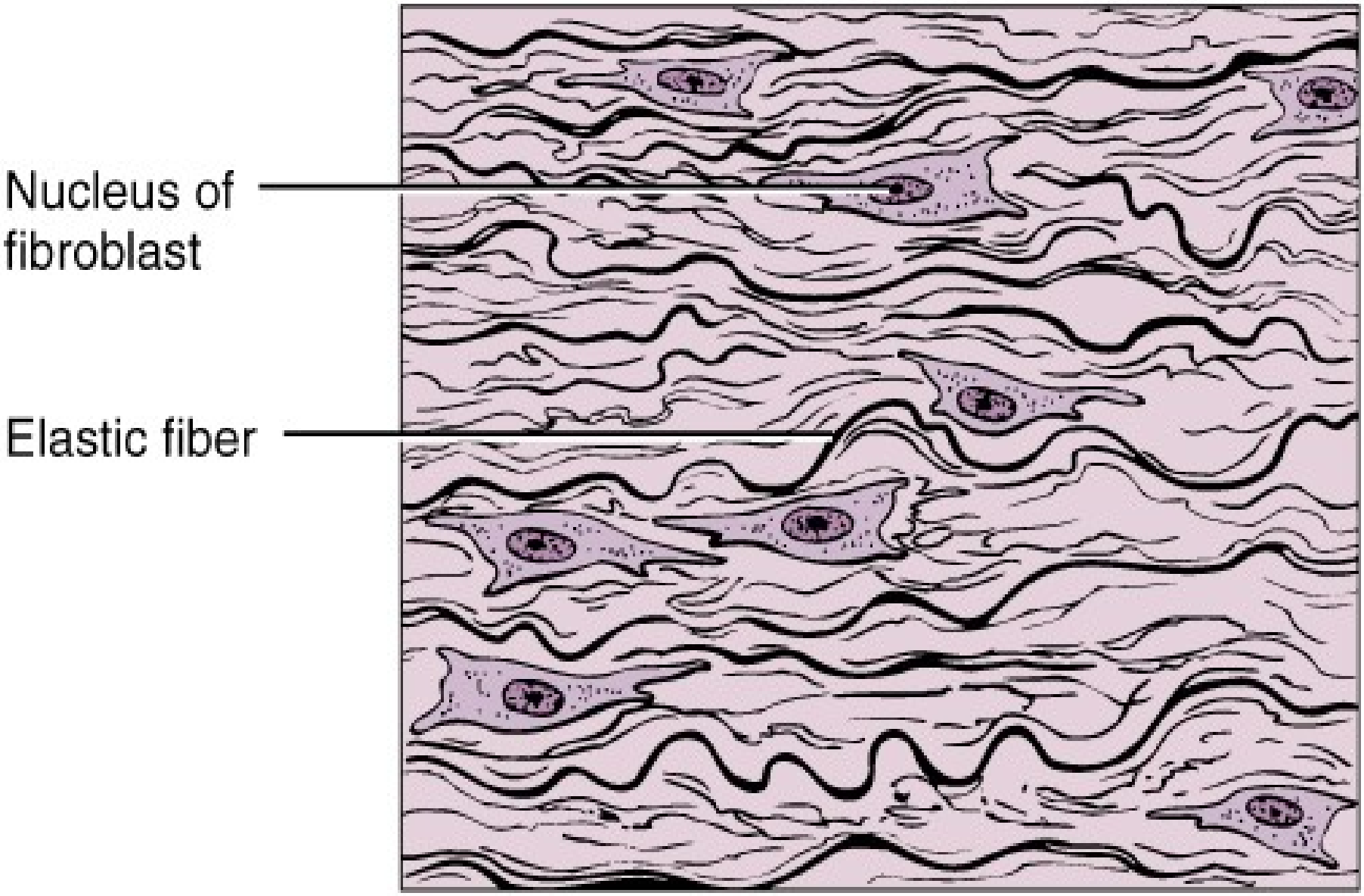
Location: Dermis of the skin; submucosa of digestive tract; fibrous capsules of organs and of joints.





Dense Elastic CT

- *Elastic connective tissue* consists of **elastic fibers** and fibroblasts.
  - It is quite strong and can **recoil** back to its original shape after being stretched.
  - It is found in lung tissue and elastic arteries.



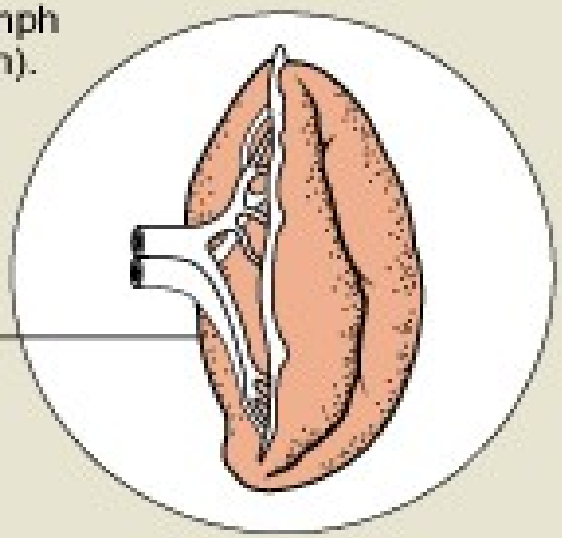
Elastic connective tissue

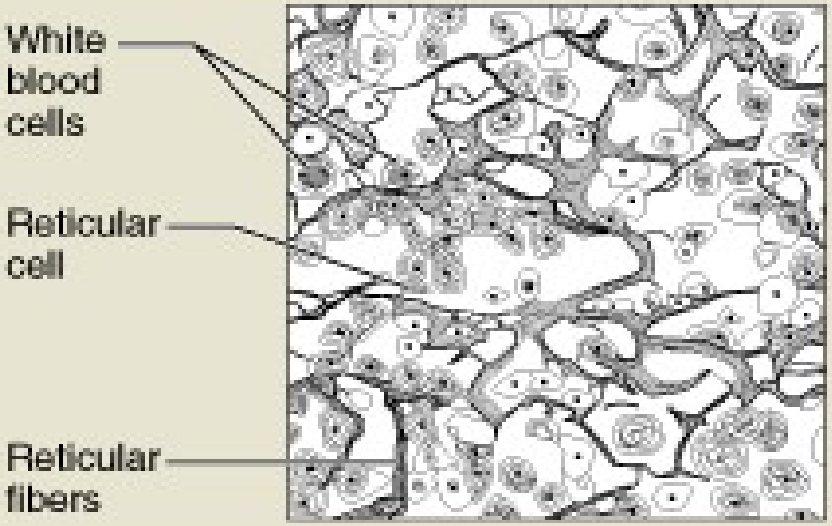
(d) Reticular connective tissue

Description: Network of reticular fibers in a typical loose ground substance; reticular cells lie on the network.

Function: Fibers form a soft internal skeleton (stroma) that supports other cell types.

Location: Lymphoid organs (lymph nodes, bone marrow, and spleen).





Dense Connective Tissue

*(1) **Regular***

composition : fibroblasts in rows between bundles of collagen fibers.

location : tendons (muscle to bone); ligaments (bone to bone); aponeuroses (muscle to muscle).

function : provides strong attachment between various structures.

*(2) **Irregular***

composition : a few fibroblasts; predominantly collagen fibers; some elastic fibers.

location : skin (dermis); fasciae; periosteum of bone; perichondrium of cartilage; joint capsules; heart valves; membrane capsules around various organs (kidneys, liver, lymph nodes, testes).

function : provides strength.

*(3) **Elastic***

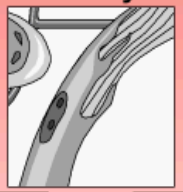
composition : fibroblasts; elastic fibers.

location : lung tissue; elastic arteries; trachea and bronchial tubes; ligaments between vertebrae; true vocal cords; suspensory ligament of penis.

function : allows stretching.

Common embryonic origin: Mesenchyme

Cellular descendants:

Fibroblast	Chondroblast	Osteoblast	Hemocytoblast
Fibrocyte	Chondrocyte	Osteocyte	Blood cells* (and macrophages)
			

Class of connective tissue resulting:

Connective tissue proper	Cartilage	Osseous (bone)	Blood

Subclasses:

1. Loose connective tissue Types: Areolar, Adipose, Reticular **2.** Dense connective tissue Types: Regular, Irregular, Elastic	**1.** Hyaline cartilage **2.** Fibrocartilage **3.** Elastic cartilage	**1.** Compact bone **2.** Spongy (cancellous) bone	**Blood cell formation and differentiation are quite complex. Details are provided in Chapter 18.*

FASICA

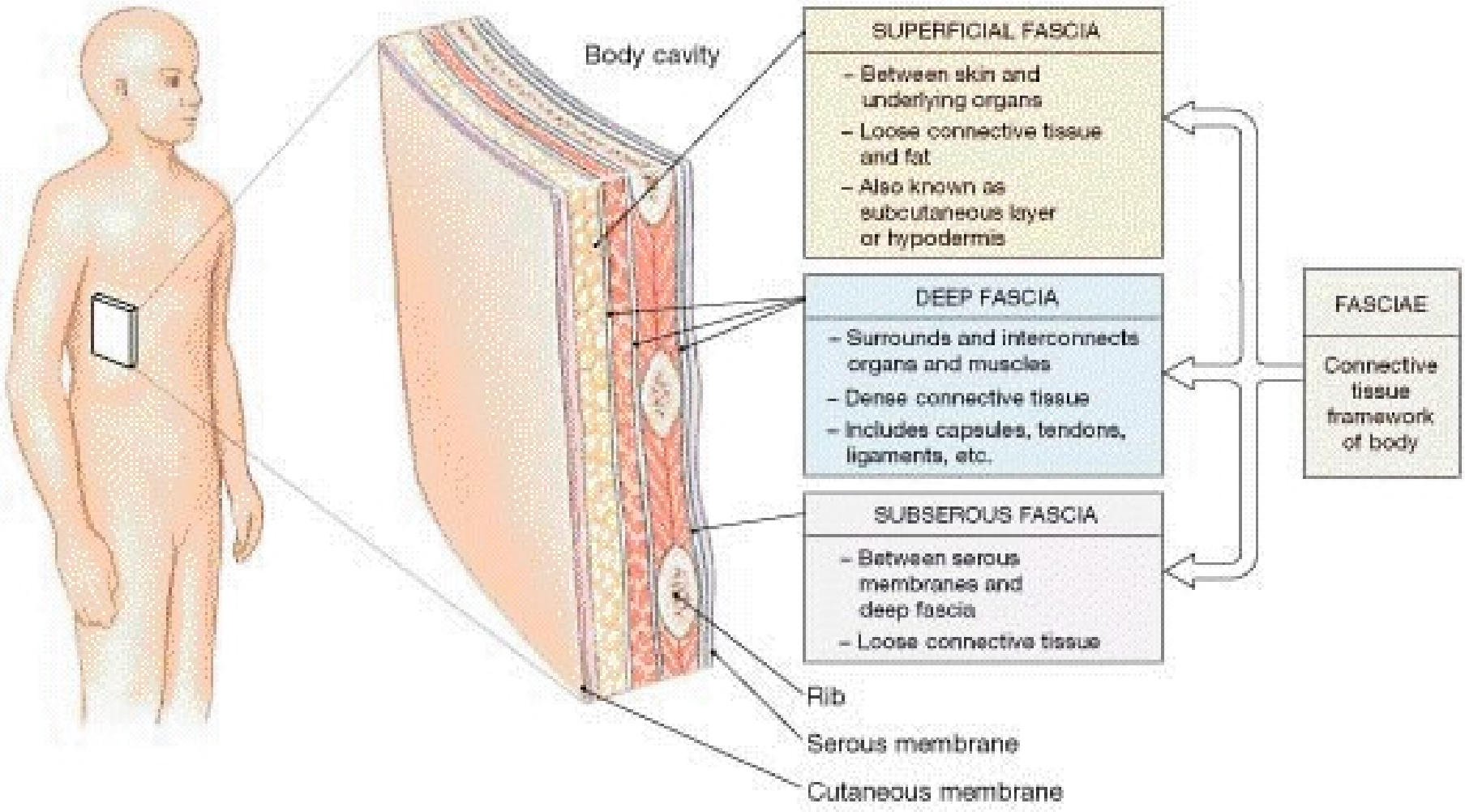


FIGURE 4-16 The Fasciae. The relationship of connective tissue elements in the body.

QUESTIONS

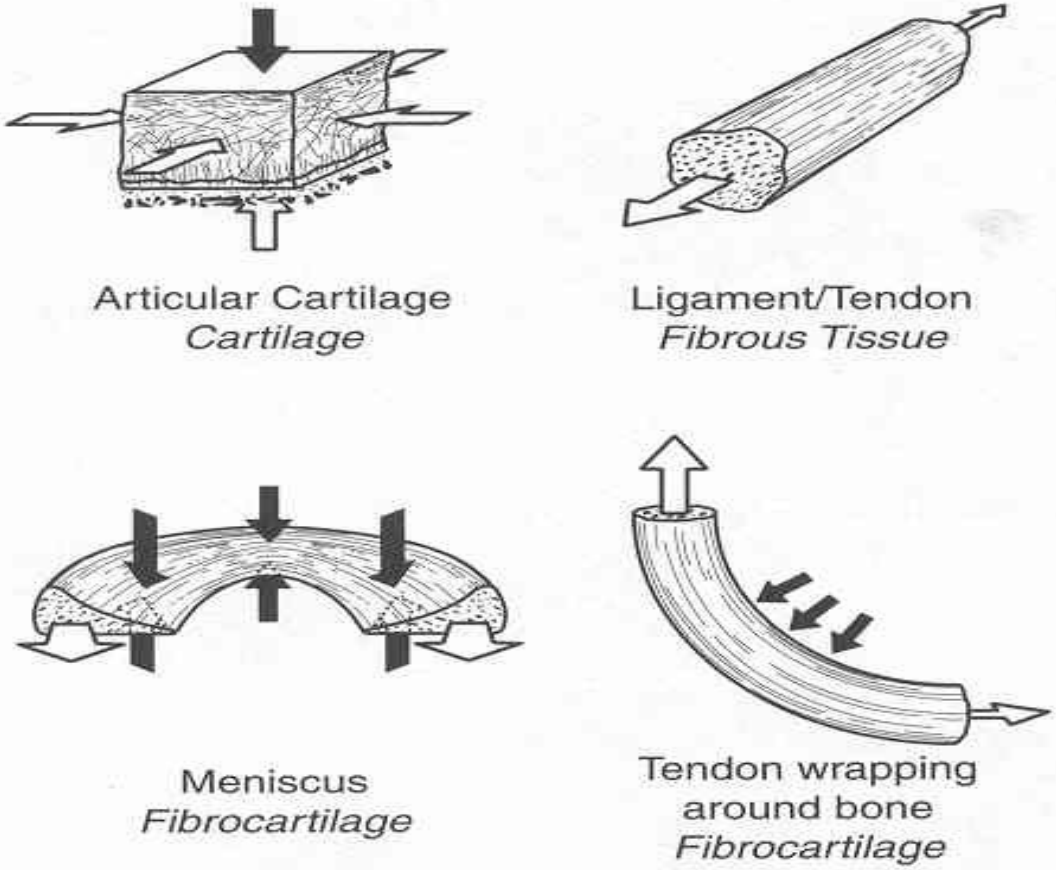
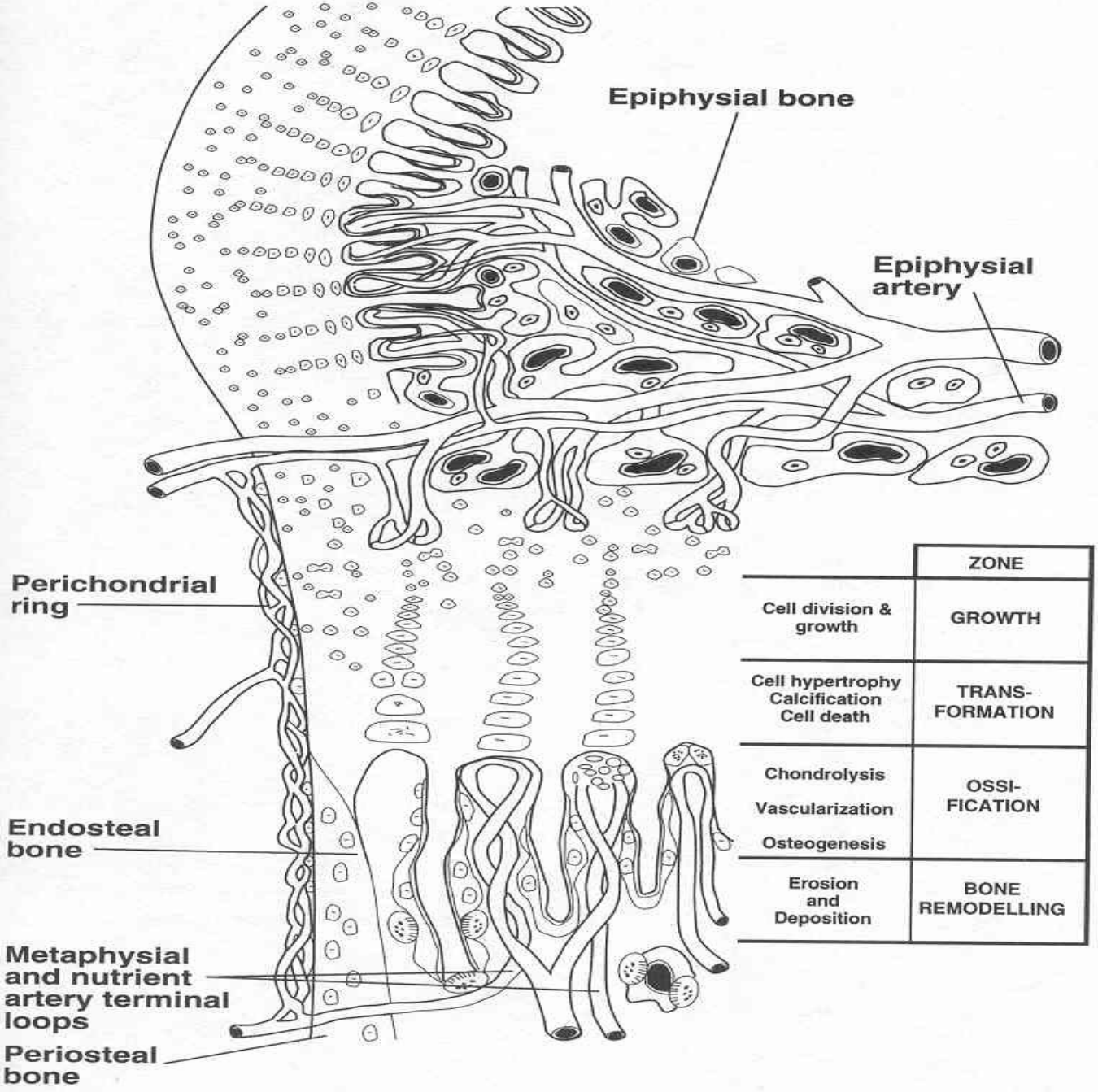


Figure 3.1. In each of the illustrations, the solid arrows represent applied "contact" forces, and the hollow arrows represent interhal tissue forces. Articular cartilage is loaded primarily by hydrostatic pressure that is created as a result of compressive loads from the joint surface. The collagen fibers in tendons and ligaments align in the direction of the axial tensile loading. Fibrocartilage is created in a tendon when compressive contact forces are imposed where the tendon wraps around a bony prominence. Fibrocartilage in a meniscus is loaded in compression but also experiences tensile "hoop" stresses under loaded conditions. The collagen fibers in fibrocartilage tissues are oriented to resist the tensile stresses (portions modified from Mow, Fithian, and Killy, 1990).



	ZONE
Cell division & growth	GROWTH
Cell hypertrophy Calcification Cell death	TRANS-FORMATION
Chondrolysis Vascularization Osteogenesis	OSSI-FICATION
Erosion and Deposition	BONE REMODELLING